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Proceedings....

TWENTY-FIRST NATIONAL POTATO UTILIZATION CONFERENCE

Fargo, N.D., July 29, 1971

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The Twenty-First National Potato Utilization Conference was held in conjunction with the 55th Annual Meeting of the Potato Association of America during the week of July 26, 1971, on the campus of North Dakota State University, Fargo, North Dakota. The papers in these proceedings are those that were presented during the utilization conference on July 29. Papers presented at the association meeting July 26 and 28 will appear in the American Potato Journal.

The material in these proceedings was provided by the speakers as a written copy of the talks they presented. Statements made in the papers are the speakers' own and do not necessarily represent the views of the United States Department of Agriculture. References, figures, and tables are reproduced essentially as they were supplied by the speakers. Numbers in parentheses refer to references at end of each paper. Mention of commercial products does not imply recommendation by the U.S. Department of Agriculture.

Sponsors of the Conference

United Fresh Fruit and Vegetable Association
North Dakota State University
Red River Valley Potato Growers Association
U.S. Department of Agriculture

This report prepared at the

Eastern Marketing and Nutrition Research Division
Agricultural Research Service

U.S. DEPARTMENT OF AGRICULTURE

600 East Mermaid Lane

Philadelphia, Pennsylvania 19118

December 1971

TWENTY—FIRST NATIONAL POTATO UTILIZATION CONFERENCE

Program and Contents

Thursday, July 29, 1971

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*This paper was submitted too late for inclusion in the July 29 program of the NPUC. It was presented Wednesday afternoon July 28 concurrently with a Potato Association of America session.

WELCOMING REMARKS

I. A. Wolff
Director, Eastern Marketing and Nutrition Research Division
Agricultural Research Service, USDA
Philadelphia, Pennsylvania

The Agricultural Research Service, as a cosponsor, once again welcomes attendants to the National Potato Utilization Conference, twenty-first in the series that began in 1948 (no conferences held in 1951 and 1955), at the Eastern Regional Research Laboratory in Philadelphia. These conferences have been held in virtually every leading potato producing area, with sponsorship usually shared by the U.S. Department of Agriculture with a State university, the local potato industry, and the United Fresh Fruit and Vegetable Association. Many of the important developments of the potato processing industry were first announced at a National Potato Utilization Conference. A prime example is the potato flakes development, first announced at the 1954 conference.

For a number of years, responsibility for organizing the conference program has alternated between the Eastern and Western Regional Research Laboratories and the conference has been held in combination with the Potato Association of America's annual meeting. This year the conference talks have been limited to the selected timely papers that can be scheduled in one day. Adequate coverage of the highlights of progress can then be accomplished with maximum time economy for attendants.

Several persons closely connected with the Potato Association of America and the Potato Conference have advanced the idea that the annual coverage of progress in utilization research should become the function of a division of the Potato Association of America. Then the program of utilization-related papers would constitute sessions of the annual Potato Association of America meeting. This proposal is the subject of current discussion and in my opinion merits adoption.

Clyde L. Rasmussen, of the Western Regional Research Laboratory, gave a talk last year that was published in the Proceedings, "Looking Back at 20 Years of Potato Utilization Conferences," in which he reviewed the evolution of the potato industry and the way progress and changes have been catalyzed and reflected by this series of conferences. Mr. Rasmussen devoted much attention to the economics of the potato industry and to the difficulties in bringing some order to the cyclic ups and downs in production and prices. There are certainly times when stored stocks of dehydrated and frozen products temporarily become excessive, and this may be reflected to some extent in prices. However, processing does tend to stabilize prices in that we are dealing with a storable instead of a perishable product.

At the time of the first conference in 1948, processing took only 9 percent of the potatoes used as food, compared with about 48 percent in 1969. Chip manufacture comprised only a fair-sized industry in the earlier year; dehydration had fallen back to a low level at the close of World War II; frozen potato products were just getting a good start. At present 2 billion pounds of frozen potato products are processed annually, having an estimated sales value (based on average prices paid by consumers and institutions) of $470 million. The total sales value for potato chips plus shoestring potato snacks reached 1 billion dollars in 1970. The demand for dehydrated mashed potatoes continues at a high level. The total per-capita civilian consumption of potatoes has increased from 107 lb. in 1954 to 116 lb. in 1969.

The latest figures available (for the 1969 potato crop) show that, as I mentioned, the total tonnage of potatoes processed nearly equaled the amount consumed from the fresh tablestock. However, demand for the freshly cooked product, on the part of those who want baked and other forms prepared directly from fresh potatoes, remains at around 130 million hundredweight per year; this is certainly a large figure by any standard. It is our firm belief that the many strides made in advancing processed potatoes in convenient forms have done much to preserve potato growers' markets by offsetting the competition of alternative foods available in ready or quick-cooking forms.

It is entirely possible that some of the ideas and developments put forth here today may become landmarks for the future. Among the subjects to be presented and discussed are: potential benefits for the potato industry resulting from implementation of the 1971 Potato Research and Promotion Act; how an executive of a large food-processing company views the shortcomings to date in achieving the ultimate in potato marketing; a new design concept in potato storage construction; and a new method for blanching french-fry slices to ensure proper browning upon frying.

Looking into the future, we see no signs that consumers will turn away from potatoes as an important part of the meal. Without anticipating too much of what Mr. Peterson may have to say later, the potato has many things going for it: it has an attractive flavor, gives mouth and appetite satisfaction, is a good source of energy and nutrients, and is an economical food. But there is never a time to rest on past laurels. Innovations and improvements are needed in potato varieties, culture, handling, storage, transportation, and processing. The rising tide of consumerism demands better quality in processed foods and increased retention of naturally occurring nutrients. Selective fortification of processed foods, e.g., vitamin or mineral addition to dehydrated mashed potatoes, could become more common in instances where nutrient replacement or fortification is expedient. There must be more affirmative action in abating pollution that arises from processing. These are some of the problems that research and development face in the potato industry and some of the problems which will continue to present challenges.

THE PROGRAM PLANNED AS THE RESULT OF THE 1971 POTATO RESEARCH AND PROMOTION ACT

(Summary)

Doyle Burns
Executive Director, National Potato Council
301 Montbello, Office Campus
45th and Peoria Streets
Denver, Colo.

The National Potato Council took the lead in advancing enactment of the Potato Research and Promotion Bill. This Bill was approved on January 11, 1971. The Act of Congress enables the establishment of a program to raise money for support of research and promotion, the money to be raised by assessment of up to 1¢ per hundredweight of potatoes handled.

Mr. Burns, as Executive Director of the National Potato Council, outlined the steps in implementing provisions of the Act, as the situation stood in late July 1971.

Following enactment of the enabling bill, the Council presented a plan for proposed research and promotion on potatoes. Hearings were held regarding the plan in Denver, San Francisco, and Washington, D. C., in early summer 1971. The briefs from the hearings then went to the Secretary of Agriculture. Assuming that the Secretary approves the plan as developed and perhaps modified, a referendum will then be called. To become effective, the proposed program must be favorably accepted in the referendum. At least two-thirds of the potato growers voting must be in favor of the program and voters must represent at least 50 percent of the potato production of the area.

Upon passage in the referendum, the program will then be administered by a Board composed of growers selected from nominations made by potato producers. All potato producers growing 5 or more acres in the 48 contiguous States are to be included in the plan. Producers not wishing to participate would be reimbursed on written request.

This new Act provides for a nationally coordinated research and promotion plan that potentially could make available for the program 1 1/2 to 2 million dollars annually.

Contracts for projects would be executed by the National Potato Promotion Board with approval by the Secretary of Agriculture. Funds collected are to go to the Board and not to the USDA. Production research will not be a prime subject of support from the funds expected; marketing research and promotion are expected to be the chief areas to benefit. It is envisioned that advisory committees are to be set up to guide the Board in establishing research projects connected with fresh potatoes, chips, frozen potatoes, dehydrated potatoes, and other potato products.

PROGRAM OF THE UNITED POTATO DIVISION

Michael Shaw
Secretary, Potato Division
United Fresh Fruit and Vegetable Association
Washington, D. C.

To outline the program of the United Potato Division, as I have been invited to do today, it would seem advisable, if not necessary, to first provide some background information. The Potato Division has long enjoyed a warm, professional relationship with just about every research, government, and industry organization that deals with potatoes. It is a giant industry and there are many who, perhaps, are not fully acquainted with who we are and what we do.

The United Fresh Fruit and Vegetable Association is an international organization of 2,600 member firms representing all levels of production, distribution, and marketing of fresh fruits and vegetables. It has been estimated that roughly 80 percent of all fresh fruits and vegetables are handled, at one time or another, by United's members. The history of United goes back to the early 1900's, but in 1944 a group of potato industry leaders met with United's executive vice president to present a proposal. Their plan was to set up a division within the association to give undivided attention to the problems of the potato industry.

The Potato Division was established and a 15-man board was elected to guide its efforts under the policies of the United Fresh Fruit and Vegetable Association. Through the ensuing 28 years, the Potato Division Board has always been comprised of industry leaders from a broad geographic area, representing all industry functions.

I might add at this point that the focus of effort is always a prime consideration of the Potato Division Board. The squeaky wheel doesn't always get the grease. Careful judgment screens the industry's needs and selects those that (a) need immediate attention, and (b) those that we can realistically do something about. We do not subscribe to demagoguery. I understand that a demagog was once defined as "a man who rocks the boat himself while persuading others that there is a storm at sea."

Broadly and briefly, some key purposes of the Potato Division are:

- To assure potato producers, shippers, and distributors recognition and representation in industry problems,
- To clarify and help bring about practical and minimal regulation,
- To offer sound, unbiased guidance on legislation affecting the potato industry,

- To increase consumption and broaden distribution of potatoes through factual advertising and education on preparation and nutrition,

- To explore fields for industrial uses of potatoes,

- To disseminate timely and accurate marketing information to division members.

In the pursuit of progress, a number of landmark decisions were made in the last 28 years. One with which you are certainly familiar was the decision to join in the sponsorship of the Potato Utilization Conference. Twenty-three years ago through the efforts of the USDA, the Eastern and Western Regional Research Laboratories, the host State's Agricultural Experiment Station, and the United Potato Division, the first Potato Utilization Conference was held. The same joint sponsorship has continued through twenty more conferences.

The wisdom of building the Potato Division into the United structure has been clearly apparent in the conduct of public relations. In 1953, United launched what was, and still is, called its Fresh for Health Foundation. It's interesting to note how the name "Fresh for Health," selected almost 20 years ago, is so ideally tailored to today's diet-and nutrition-conscious consumer. Potato photos, recipes, and releases were, and continue to be, supplied to all major newspapers, and radio and television stations. In this way, food editors can personally byline top quality editorial and photographic material with the assurance that they will have the exclusive for their city. Does it work? Our Fresh for Health files contain thousands of clips and compliments from food editors. To cite only one recent example, a leading San Antonio newspaper had a full-color, full-page food section feature on page 1. The name of the feature was "Potato--King of Food Crops." This prime space and the color plates would cost between $1,000 and $1,200 if they could be bought, but front pages of food sections can't be bought. Incidentally this entire Fresh for Health program is financed by voluntary contributions from industry members. The cost in the case of potatoes is about one cent per ton.

Over the years, other Potato Division projects have included:

1. Truckside posters.

2. "Potato Sack-Fax" (potato facts for printing on supermarket bags).

3. "Potato Cook-Fax"(for packers interested in printing tested potato recipes on consumer packages).

4. A 6-minute color TV film on potatoes.

5. A 48-page publication on potatoes as part of the 79 commodity series, "Facts and Pointers."

6. A publication entitled "Where to Find the Answers About Marketing

Fresh Potatoes."

7. Special study reports on color and wax, on preparation cost, and on packaging.

8. Publication of a weekly bulletin, "Spudlight," containing from 4 to 8 pages of information gathered from all sources including exclusive firsthand market news phoned in just hours before press time. This year Spudlight's 50 issues will constitute a volume estimated at 250 pages.

9. A 2-part Certified Seed Report totaling 36 pages made possible by close cooperation with all State seed certification officials. The August issue contains summaries of all seed potato acreage entered for certification--by States and by varieties. The December issue contains all data on acreage passing certification.

10. A current project started this year is called "Producing Area Profiles." This could well be one of the most significant projects undertaken by the Division from the standpoint of having total production and marketing information at fingertip availability. Every major producing area in the United States will be represented in "Profiles." A 4- to 6-page summary will show the precise location and extent of acreage, varieties, marketing times, types of pack, method of shipment, extent of processing activity, along with other key data and a historical "thumbnail" sketch of the area. So far, data on 14 major producing States were condensed to 2 pages each as a visual guide and bench mark for data presented in the "Parade of States" feature at the general meeting of the Potato Division. Data on two States, California and Texas, have been expanded and published in Spudlight. Others will follow on a regular basis as information is received and incorporated.

11. Legislation is and always has been key responsibility. Activity in this area is constant. United has been active in service on advisory committees to Federal agencies in drafting legislation, in testifying before committees and in hearings, and in suggesting member action. The range of legislation includes farm labor, collective bargaining, pesticides and environmental control, permanent strike legislation, occupational safety, packaging and code dating, fair labor standards, and others.

Our very latest project is one that locks right in on an existing situation that is a concern and an opportunity. The situation is the food attitudes of young people. A film-strip kit with 2 complete programs focuses directly on the student and young homemaker. The kit contains a total of 81 frames and 27-1/2 minutes of professional narration on disc and cassette tape. One program is titled "The Wonderful World of Freshness" and the other "Creative Meal Planning." What about potatoes? You bet they're included in this A to Z kit.

This, in the relatively short time available, is where we've been and where we are. Where do we go from here? Well, it would be presumptuous for me to think that my ability to prophesy is any better than, for instance, Dr. Simon Newcomb, Director of the Naval Observatory who, in 1883 said, "We are probably nearing the limit of all we can know about astronomy."

Or, Thomas Edison, who in 1889 said, "I have always consistently opposed high-tension and alternating systems of electric lighting...not only on account of danger, but because of their general unreliability and instability for any general system of distribution.

Or, Dr. Max Planck, Head of the Physics Department of the University of Munich, who in 1875 said, "All the important discoveries in physics have been made."

Or, Daniel Webster in a Senate speech on March 23, 1848, who said, "I have never heard of anything more ridiculous, more absurd and more affrontive to all sober judgment than the cry that we are profiting by the acquisition of New Mexico and California. I hold that they are not worth a dollar."

Or, finally, our own U.S. President Martin Van Buren who in 1829 said in a letter to then President Andrew Jackson, "As you know, Mr. President, railroad carriages are pulled at the enormous speed of 15 miles per hour by engines, which in addition to endangering life and limb of passengers, roar and snort their way through the countryside, setting fire to the crops, scaring livestock and frightening women and children. The Almighty never intended that people should travel at such breakneck speeds."

Rather than prophesy on what the future may bring, let's simply say that there is a reasonable certainty that 1971 United States potato production will be in the neighborhood of 315 million hundredweight, based on the latest available information. The job of the United Potato Division is to continue using its full resources to provide leadership and guidance toward an orderly and economically realistic marketing of this crop. Our goal is to make our members the best informed and best represented industry members while stimulating consumer interest to help pull potatoes and potato products through consumer channels.

The Division will also continue its support of valuable industry efforts, such as this Potato Utilization Conference. As the Conference goes into the transitional stage of being incorporated into a solid 3-day session with other fine PAA papers, the United Potato Division extends an offer of its staff effort in the hope that it may contribute to new record levels of industry participation and success.

EXTENSION ACTIVITIES IN MEETING EDUCATIONAL NEEDS OF RED RIVER VALLEY POTATO GROWERS

E. S. Plissey
Area Extension Agent, Potatoes
University of Minnesota-North Dakota State University
Red River Valley Potato Research Center
East Grand Forks, Minn.

This talk is a "first" in that I believe the Utilization Conference never has had an extension worker talk about his own profession. We were discussing the need for more extension talks at PAA meetings at the Extension Committee meeting this morning, and thought perhaps we needed to let the Association and the Utilization Conference know a little bit more about extension activities. I am going to do just that, but I will be talking about utilization too, and that is perhaps why my talk is scheduled before the Utilization Conference. However, instead of talking about the utilization of the potato, we're going to be talking about the utilization of information by those people who produce the potato.

In the early 1960's, organization teams of various extension administrators around the country were spending a good deal of time in meetings and conferences discussing the future of the role of Extension Service activity in meeting the needs of commercial farmers and ranchers. One of the publications that came out of this work was a study titled "The Extension Responsibilities in Meeting the Needs of Commercial Farmers and Ranchers," and I believe that the position that I am now holding is also a result of the work of this particular Federal and State Administrative Committee on Extension Work.

In 1966, the Red River Valley Potato Growers Association, working with the Red River Valley Sugarbeet Growers Association, became very active politically in attempting to establish some improved extension type of informational services for their two groups of growers. Through the efforts of State university administrators and the various producer groups that got involved, enabling legislation was passed in both the Minnesota and North Dakota Legislatures creating two additional extension worker positions that would work across State lines, serving both the Extension Services of Minnesota and North Dakota.

One of these positions became the Red River Valley sugarbeet specialist position and is currently being filled by Mr. Jerry Smith. It is housed here at the North Dakota State University. The other position of area extension agent is housed at the Red River Valley Potato Research Center and is being managed by the Minnesota Agricultural Extension Service. I am the lucky person that got to fill this job. Had I known how big the area was and how many people there were involved, I think I would have done more fishing in Northern Aroostook County, Maine, and stayed where I was.

The position of area potato extension agent for Minnesota and North Dakota is an industry "first." I believe that nowhere else in the country is there an extension potato position serving two States. We have had some little problems but no real big problems, and I believe we have created some excellent educational programs. These programs have been of benefit to not only the producers in the Red River Valley, but to allied industry groups that serve the producers and also to some of the people involved in marketing the crop. The educational programs have aided the County Extension Agents, who have real serious shortcomings in their training in the potato enterprise and in their knowledge of potato information needed by the industry growers they are serving.

The Red River Valley Potato Extension Agent serving the potato industry is housed with the Red River Valley Potato Growers Association at the Potato Research Center, which picks up the tab on such major expenses as mileage, hotels, meal expenses, telephone and secretarial services. In functioning in this manner, the Growers Association is probably assuming a similar role to that of local county committees, or a local county commissioner group. North Dakota State University and the University of Minnesota share the salary costs equally. The administration of the position is carried out by the Director and Assistant Director of the University of Minnesota Agricultural Extension Service. Program direction also comes quite significantly from the Extension Service of North Dakota State University, which functions very strongly in the development of our educational programs and in the presentation of these programs.

We have had some excellent experiences in setting up proper working relationships with various industry groups. The first thing that we did in order to get our program rolling was to establish a Potato Advisory Committee. The directors of the two State universities selected grower, university, industry, and USDA staff advisory representatives to assist in position development and to serve in an advisory function in suggesting areas of program emphasis and areas of new educational programs that could be attempted.

In our efforts in conducting educational programs here in the Valley, we have attempted to make presentations and consultations with the growers in a manner that was not typical of extension in the past. For example, in our work in the control of potato weeds, diseases, and potato insects, we have used intensive workshops and intensive series of meetings to carry out educational programs instead of single, hard-hitting sessions. We find these intensive workshops, where a good deal of background information is presented to the grower in workbook and workshop form, have paid off in that the growers seem to be better informed about the problems that confront them. They also seem to be making some of the decisions that we hoped they would be making in overcoming their problems, particularly decisions on disease and insect control and in improving stands and yields of the crop here in the Valley.

It is difficult for one person to assume the credit for this particular extension position, because there are several persons who have held major responsibilities in programming that have helped make the position become quite successful. I would like to name a few. Dr. O. C. Turnquist, who was honored last night by the Utilization Conference, should be commended for the great deal of time that he has put into making this position a success. Dr. Turnquist serves as Extension Horticulturist in Minnesota. All the Extension Specialist staff at North Dakota State University involved in the potato crop, and many of the researchers, have given much of their time in presentations at meetings and in program planning to make the extension position successful. Also in Minnesota, Dr. Howard Bissonnette, our Extension Plant Pathologist, working on the potato crop, has given a good deal of leadership to our Disease Workshop program and to our informational programs on potato disease development.

My extension position is housed at the USDA Potato Research Center with the Red River Valley Potato Growers Association. It was felt that the position could take some of the extension-type workload off the staff of the USDA personnel housed there. For many years, the personnel at the Center have been doing a banner job of helping growers with their problems on potato culture, their storage construction and management problems, and many of their market quality problems. We had hoped that this extension position would alleviate some of the load. Frankly, I feel we have created more headaches for the Research Center staff than ever before because of the increase in the number of people coming to the Center for information.

We work very closely with the Red River Valley Potato Growers Association at their Research Farm, which many of you had the opportunity to see on our tour Tuesday.

The Area Extension Agent cooperates with Dr. Turnquist in the conduct of his varietal demonstration work and also with most of the other research and specialist staff in conducting various test-plot activities, including fertility work, fungicidal work, the use of soil fumigants, and also varietal demonstration and insecticidal work.

Plot harvest is always a big problem for our staff, and I certainly like to lend a hand helping our local staff and the staff of the North Dakota State University and the University of Minnesota.

We also conduct demonstration work with cooperating agricultural chemical suppliers on growers' farms. We attempt to achieve as much grower cooperation as possible right in the counties where potatoes are being grown most intensively because we feel that the educational efforts will pay off the quickest there. New practices seem to develop rapidly with producers here in the Valley, and we attempt to emphasize these practices through the Red River Valley Potato Growers magazine and through grower meetings.

One typical new cultural practice that is developing and coming on fast in the Red River Valley involves the laying out of potato rows and the application of fertilizer prior to the planting operation. This particular operation allows the planter to cover three miles without refilling and adds considerable efficiency to the planting operation.

We utilized the technique of aerial infrared photography in predicting and pointing out late blight outbreaks. Dr. Howard Bissonnette and the Thompson Hayward Chemical Company have contributed banner assistance to this effort. I feel that we are making real progress in that we now have aerial applicators utilizing this technique to help provide information to growers on blight situations developing in the field.

In one instance, in a small field in East Polk County, Minn., we were able to spot late blight early with infrared photography, and by the end of the season the grower had controlled this disease situation, harvesting a fairly decent quality crop despite the bad blight outbreak earlier.

We have also utilized demonstration plots quite successfully throughout the Red River Valley. Weed spray demonstration plots, vine killing plots, and insecticide plots have all been used.

Follow-up twilight meetings are held at these plots and the growers seem to receive these evening meetings very well. They have the opportunity to get down in the rows and actually see the treatments working, or to count the insects, or to evaluate the blight and disease control practices. I think that these meetings have helped our educational programs move a good deal faster and have encouraged earlier adoption of approved practices.

We have worked quite extensively with soil fumigation for wilt control with Dr. Bissonnette's cooperation. We are attempting to achieve better control of rhizoctonia, verticillium and the fusarium wilts, but we have a long way to go in developing an acceptable soil fumigation program here in the Red River Valley. The performance of the materials we have used has not been satisfactory; moreover, their cost may be excessive at rates growers would have to use in order to achieve successful wilt control.

We have also applied extensive weed control demonstration plots at various county locations and have experienced a terrific amount of cooperation by the County Agent staff in the Red River Valley area. Incidentally, we work primarily in 22 counties and function quite well with 22 county agents and 30 extension specialists and a good many research team members from both the State universities and the USDA.

At our educational meetings conducted in the wintertime, we attempt to emphasize the adoption of improved production practices and to encourage grower adoption of better disease and insect control techniques. I hope that we have been successful; I personally see a great deal of progress.

Another technique that has been used quite successfully has been to cooperate with aerial applicators in adjusting and calibrating their airplane equipment to achieve better fungicidal, herbicidal, and vine-killing results. Aerial applicators cooperating in these programs report the results are paying off very successfully in improved control of disease and insects.

I want to stress that without the excellent cooperation of the Growers Association, the Extension County Agents, the specialist staff, and the administrators of extension activities here at our two State universities, we would have had considerable difficulty launching the Red River Valley Extension Potato position. However, we have been very successful, and I hope that our programs will continue as well in the future.

POTATOES: THE MISUNDERSTOOD FOOD

J. R. Peterson
Grocery Division
The Pillsbury Company
Minneapolis, Minn.

May I speak for the Pillsbury Company in expressing a deep appreciation for the invitation to join your conference today? It is a pleasure to share our thoughts on this important food with you. By way of presenting our credentials, I would like to mention our involvement in this most important business.

1. We market dehydrated potatoes in the retail market under the Hungry Jack label. We are presently completing construction of a new potato-flake plant 80 miles north of here at Grand Forks, N. D. This construction includes processing, packaging, finished goods, raw potato storage, and office buildings. We feel this 35,000,000-pound annual capacity plant is the most modern, up-to-date plant in the industry, meeting all sanitation and environmental regulations expected for at least the immediate future.

2. Our Burger King restaurants are major users of frozen french fries. We had 763 of these fast-food units in operation on June 1 and plan to open 100 more of them in the next 12 months. Their potato usage is approximately 80,000,000 pounds annually and is climbing rapidly.

3. In addition, we use potato flour and are presently experimenting with various other forms of potatoes in the United States and abroad. With this level of involvement, we are vitally concerned with the future of the processed potato as a food in today's modern convenience world.

Potato processing dates back to at least 200 A.D. when the natives of Peru found a way to dehydrate potatoes by allowing them to freeze at night and thaw during daylight hours. This cycle was repeated again and again with the juice being expressed from the thawed potatoes by treading on them with bare feet. We still find an occasional ex-G.I. who thinks that's how the World War II dehydrated potatoes were manufactured.

Fraser in 1794 recorded how potatoes were dehydrated to form potato flour or meal, extending the shelf life. Little was accomplished from that time until World War I when dehydrating plants were built for manufactured dried potatoes in United States and Europe. After World War I the potato processing industry disappeared except for the production of potato flour. The processed potato industry reappeared during World War II and continued to grow from that point until today when over 50 percent of the potatoes consumed are processed.

What has history taught us about potatoes?

1. For years potatoes were thought of as being old-fashioned in a society that values the contemporary.

2. Potatoes have been culturally associated with diet patterns of less affluent times and for less affluent people. Traditionally, the starch and grain component of diets is inversely related to economic trends. The higher the real standard of living, the more diets shift to other preferred sources of food, primarily meat protein.

3. Potatoes in their original form are inconvenient and timely in preparation. Inconvenience is counter to the emerging trend in a society where women's roles have been changing and are continuing to change at an increasing rate. The woman's investment of time and energy in food preparation is no longer as highly valued as it was several generations ago, and the demands on women's time for other activities are increasingly valued.

4. Technology introduced convenience to potatoes via the development of potato chips, frozen french fries and dehydrated mashed potatoes. (See figure 1.) As this chart illustrates, the effect of this product development and marketing effort has been to arrest the downtrend of per-capita consumption of potatoes and to turn the trend upward from the mid-1950's, when the impact started to become measurable. Per-capita consumption has been on the increase for the past 20 years. This increase in the consumption

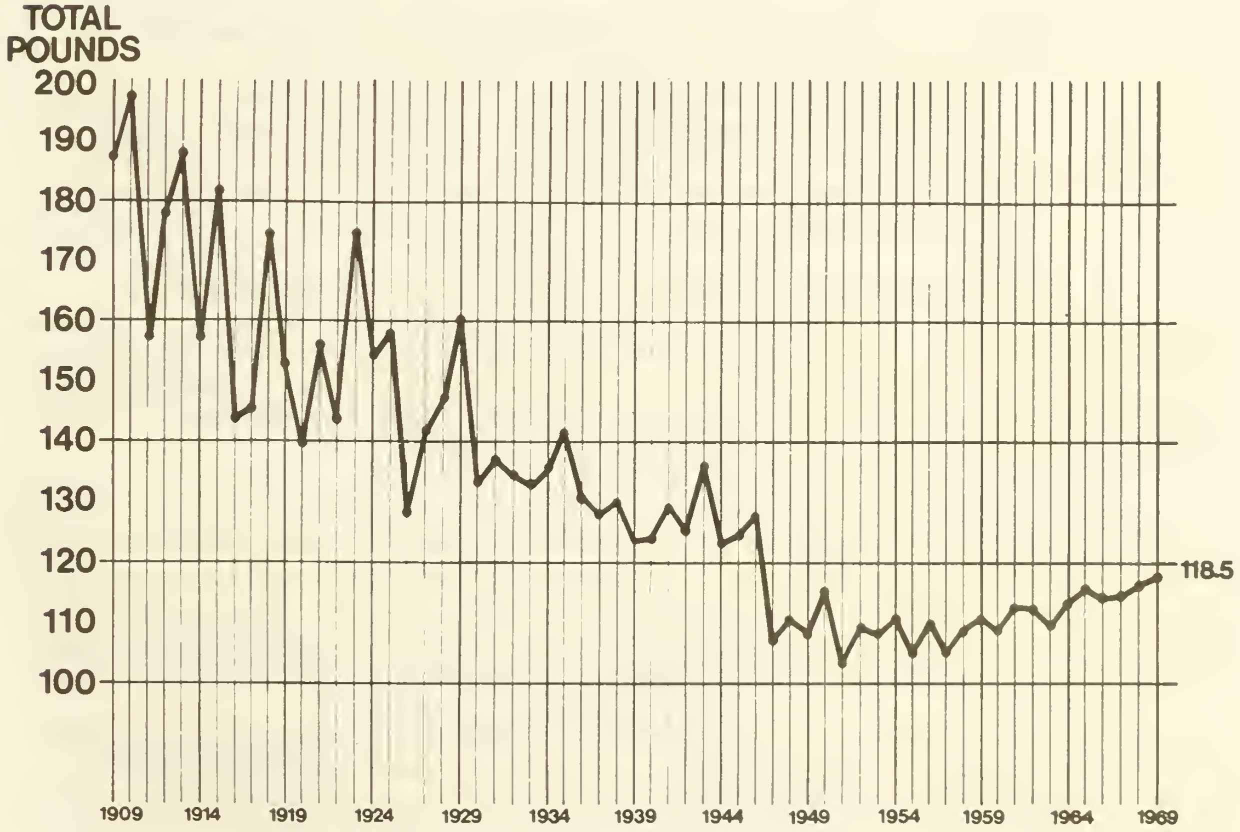

Figure 1.--Per-capita consumption of potatoes, 1909-1969. Source. U.S. Department of Agriculture.

of potatoes has brought a greater degree of order into the marketing process. The swings in the market have been less severe.

Figure 2 identifies the degree of growth of processed potatoes -- an increase of almost fourfold since 1956. Figure 3 shows that the percent of the total consumption of processed potatoes has increased rapidly, reaching 47 percent in 1969 and, as closely as can be estimated, approximately 50 percent today.

5. Technology provided this service at a reasonable cost/benefit relation which continually improved as consumption of these technologically oriented products increased and as the competitive pressures of a free marketing society stimulated increased efficiency in the production and distribution system. Today, dehydrated mashed potatoes cost little more than fresh potatoes mashed in the home, as figure 4 shows. The services and benefits of this processing are in essence "free" to the consumer.

6. While the primary thrust of technology was to provide convenience, we gave great priority to the issue of quality of the processed product available to consumers. This is a product that in its fresh form varies greatly in quality during the year, and processing stabilizes quality at a high level. Given proper priority, improved processing technology has consistently moved the quality of the product upward from its relatively poor initial position in the dehydrated form. However, there is still a great deal to be learned and applied in this area.

7. Because of the cultural familiarity of the product and its low price, the market penetration of dehydrated potatoes has been relatively equal in all socio-economic groups, as shown by figure 5. This is in sharp contrast to the penetration of new foods that are culturally unfamiliar, where the impact has been at the high end of the income scale. The result has been of relatively equal benefit to the groups needing the nutrition most -- the low income groups.

As a part of their antiaffluence image, potatoes are primarily thought of as a way to fill your stomach and as being fattening in a culture that is increasingly coming to believe that "being fat is bad." At this point, I think we must ask ourselves, "Do potatoes fit today's contemporary style of living? Are potatoes the misunderstood food? Do consumers understand the role that potatoes play in the U.S. diet?"

Let's look at figure 6, which shows the nutritional value of potatoes. An average serving of mashed potatoes (4 oz. or about 1/2 cup) would range between 74-140 calories depending upon the milk and butter additions. I have included examples of a number of other foods commonly found in diets as reference. As you can see, potatoes, except for chips and french fries, are at the low end of the calorie scale for these basic foods.

A second issue deals with the type of carbohydrate found in potatoes, grains, and legumes. In these foods, the carbohydrates are complex. This may be of importance in dealing with heart disease and arteriosclerosis. A study in Framingham, Mass., was begun in 1949 on 5,127 men and women, aged

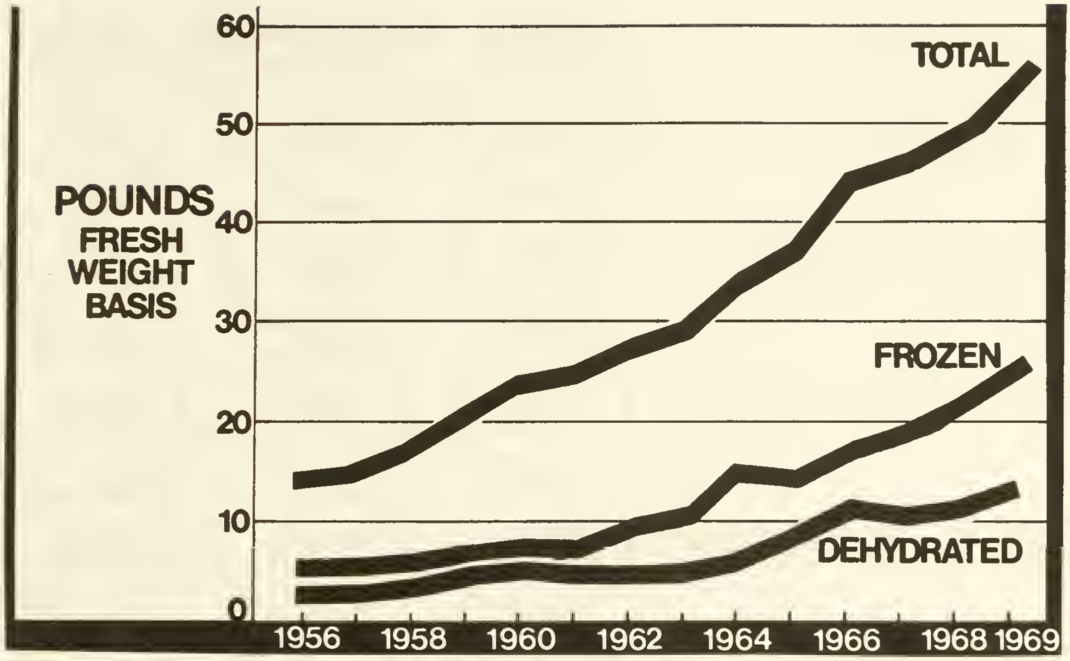

Figure 2.--
Per-capita consumption of processed potatoes, 1956-1969.
Source: U.S. Department of Agriculture.

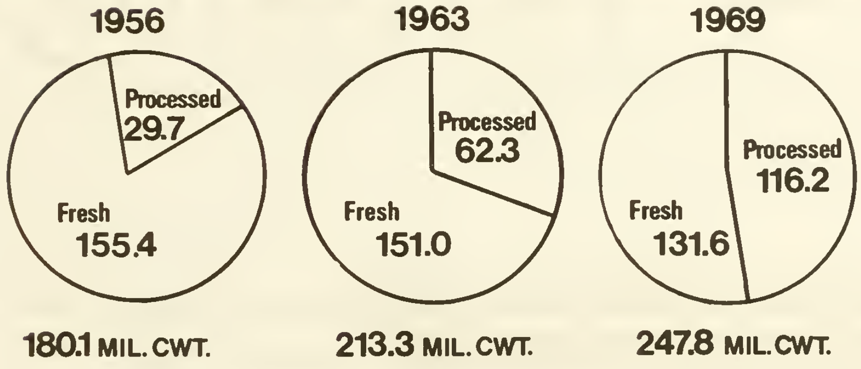

Figure 3.--
Potatoes used for food, fresh and processed, 1956, 1963, and 1969.
Source: U.S. Department of Agriculture.

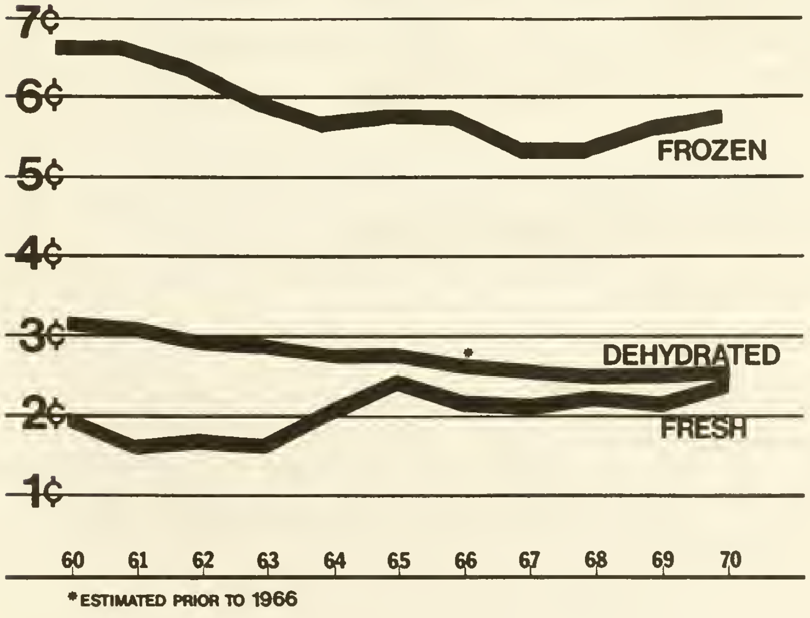

Figure 4.--
Cost per serving by type of potatoes, 1960-1970.
Source: U.S. Department of Agriculture (fresh and frozen), MRCA (dehydrated).

INCOME	FRESH	DEHYDRATED	FROZEN
Under $4,000	97	96	57
$4,000 to $7,000	101	91	85
$7,000 to $10,000	102	105	129
$10,000 to $15,000	101	108	124
$15,000 and over	95	109	123

Figure 5.--Potato consumption index by income group. Source: MRCA Menu Census 1968.

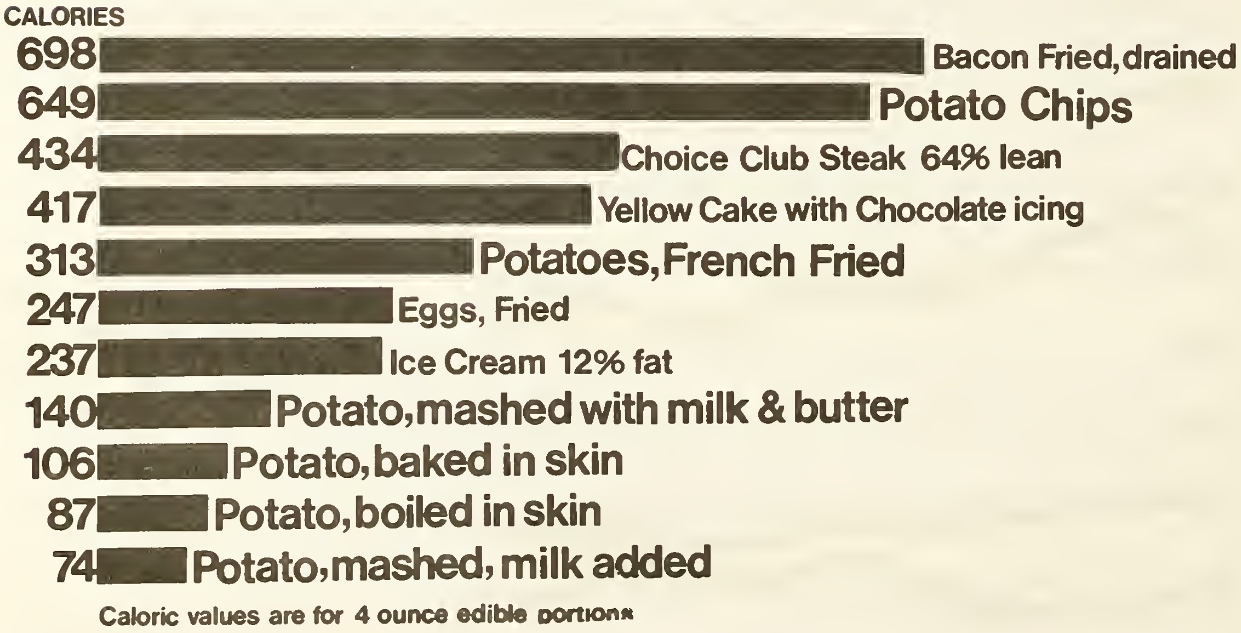

Figure 6.--Calories in potatoes and other foods. Source: Agricultural Handbook No. 8, USDA, Agricultural Research Service.

30 to 62, to determine their development of coronary heart disease and other arteriosclerotic conditions. The results of this most comprehensive study of cardiovascular diseases are now being reported. The Framingham study suggests that there is a nutritional difference between simple carbohydrates and complex carbohydrates. Sugar is a simple carbohydrate, being chemically one glucose unit, while cereal, bread, potatoes and legumes are complex carbohydrates, having more than three glucose units. Based on this study, potatoes offer a food that is a complex carbohydrate containing almost no fat -- a perfect substitute for sucrose in providing the daily energy our bodies need. We believe the results of the Framingham study and additional studies underway in this area will prove to be of major importance to potatoes and other complex carbohydrate foods in the future.

Potatoes are misunderstood in other nutritional aspects. They are not commonly recognized as an important source of vitamin C, vitamin B_6, folacin, niacin, vitamin B_1, phosphorus, magnesium and iron. Potatoes, in fact, represent a greater source of ascorbic acid (vitamin C) than orange juice does in the United States diet. Table 1 shows the summary of our findings for the 10 vitamins and minerals found in significant quantities in potatoes for which a recommended dietary allowance has been established.

TABLE 1.--Vitamins and minerals in one serving (4 oz.) raw potatoes ("newly harvested")

	Amount	Percent MDR	Percent RDA**
Vitamin C	30mg.	100	50
Folacin	16mcg.		15
Niacin	1.7mg.	17.1	9.5
Vitamin B_1	114mcg.	11.4	8.1
Vitamin B_2	46mcg.	3.8	2.7
Vitamin B_6	0.57mg.	*	28.5
Calcium	13.7mg.	1.8	1.7
Phosphorus	68.4mg.	9.1	8.5
Iron	0.68mg.	6.8	6.8
Magnesium	34mg.	*	9.8

*No minimum daily requirement established.

**Recommended dietary allowance as established for a reference man (age 22, living in the USA) by the National Research Council, 7th edition, 1968.

Figure 7 shows that some of the nutrients in the original fresh products are lost during storage and processing either in the home or in the manufacturer's processing procedure. We are now able to replace lost nutrients and to restore the nutritional contribution of processed potatoes to equal that of newly harvested potatoes.

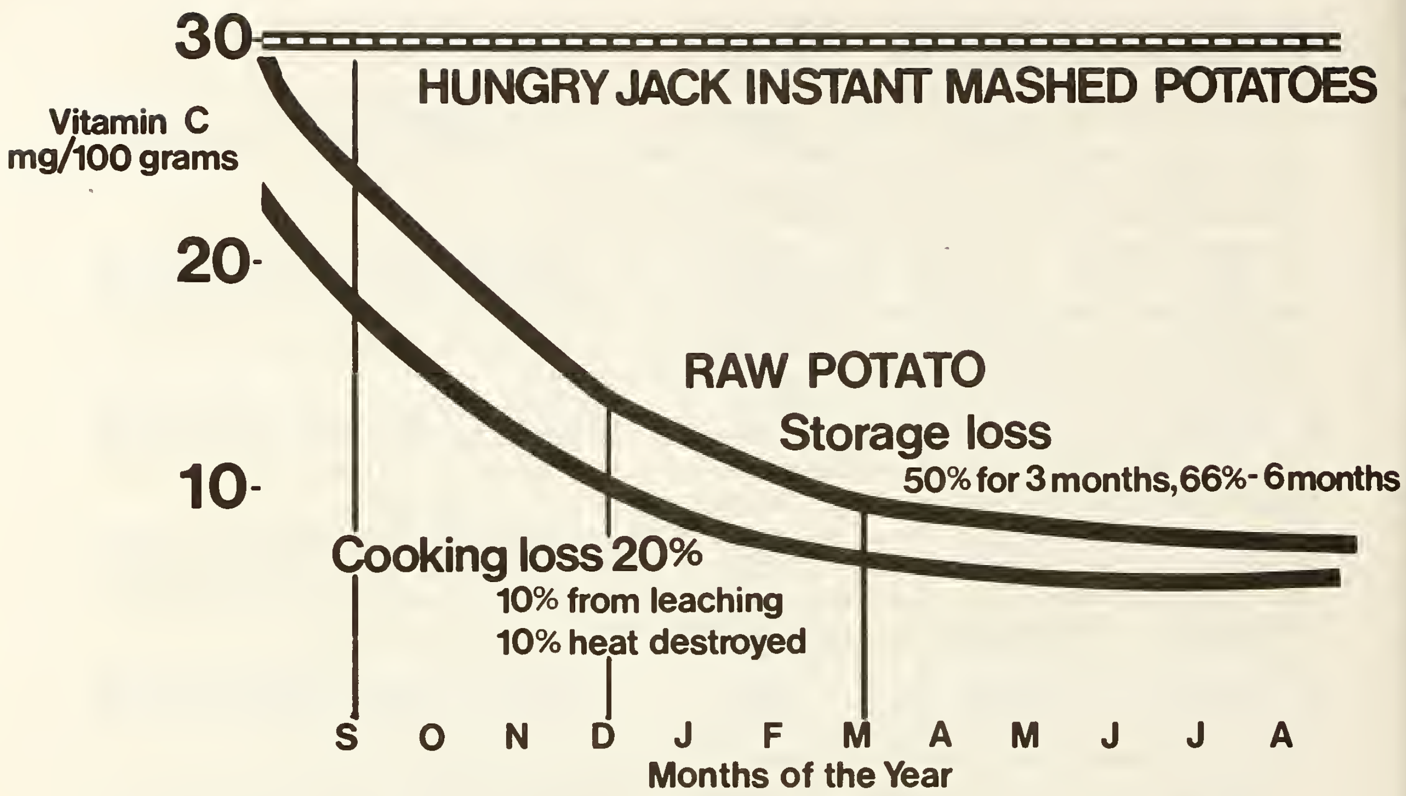

Figure 7.--Vitamin C loss in storage of fall crop potatoes. Source: Agricultural Handbook No. 8, USDA, Agricultural Research Service.

As an example, in January, a consumer preparing Hungry Jack Instant Potatoes would obtain 30 mg. of vitamin C per 100 gm. of potatoes, while if she prepared mashed potatoes from the fall crop of raw potatoes, she would obtain only 8.5 mg. on the average because of storage and cooking losses. The nutritional restoration of processed mashed potatoes has provided the consumer with a product that is more nutritious and convenient than its aged raw counterpart.

We believe that all processed potatoes should be nutritionally restored to "newly harvested raw potatoes." If the consumer is to receive the true value of the potatoes she consumes, they should be restored, if at all possible, to their most ideal condition -- in this case to the nutritional level that they were found in when newly harvested. We have done a considerable amount of work in establishing the vitamin and mineral levels for a newly harvested raw potato. Table 2 shows how we have restored the vitamins and minerals to Hungry Jack Instant Potatoes. You will note how the milk and butter provides additional nutrition to prepared mashed potatoes. We have restored all vitamins or minerals that are found in potatoes in meaningful quantities. We have not restored iodine because FDA regulations prohibit this except for special dietary foods. The delicate issues of iodine and vitamin A are broadly recognized.

TABLE 2.--Nutritional restoration of dehydrated potatoes

Vitamins and minerals	One serving (4 oz.) newly harvested raw potatoes	HUNGRY JACK	
		One serving (4 oz.) unprepared flakes	One serving (4 oz.) prepared with butter & milk
	Percent Recommended Dietary Allowance		
Vitamin A	0	0	5.5
Vitamin D	0	0	3.2
Vitamin C	50	50	50
Vitamin B_1	8.1	8.1	8.5
Vitamin B_2	2.7	2.7	5.3
Vitamin B_6*	28.5	28.5	29
Folacin*	15	15	15
Niacin	9.5	9.5	9.5
Calcium	1.7	1.7	6.4
Phosphorus	8.5	8.5	13.4
Iron	6.8	6.8	6.8
Magnesium*	9.8	9.8	10.8

*Vitamin and mineral levels represent a composite of values for a number of potato varieties, field locations, and crop growing conditions.

As I said earlier, we believe a substantial amount of communication must take place, telling the consumer of the nutritional benefits of potatoes. The "nutritionally restored" Hungry Jack Instant Potatoes that we will be marketing this fall are being labeled to provide the full information given in table 2 on vitamins and minerals relative to a "newly harvested raw potato."

We then provide the consumer with information on the caloric values, shown here in table 3, so she fully understands the effect of adding milk and butter to potatoes. Thus she can make a caloric comparison with other foods. We also include sodium values for those on low sodium diets.

TABLE 3.--Nutritional composition of Hungry Jack Mashed Potato Flakes when prepared according to suggested recipes (approximate values for each 4-ounce serving.)

Ingredients	Calories	Sodium
Potato flakes	68	23 mg.
Whole milk	20	15 mg.
Butter (1 1/2 tsp.)	52	69 mg.
Salt	0	233 mg.
Prepared potatoes	140	340 mg.

We also provide a verbal explanation on why we are restoring Hungry Jack potatoes, emphasizing that the restored product contains 50 percent of the recommended daily allowance of vitamin C. We believe the labeling provides a full disclosure of the nutritional role potatoes contribute to the daily diet and is a meaningful step in educating the American consumer.

On the front panel we summarize our position in this nutritional statement: "Nutrition of fresh potatoes, 50 percent recommended daily allowance of vitamin C. See side panel." We would like the consumer to read the explanation of the "restoration principle" stated on the side and back panels for a full understanding of what we are providing for her.

In summary, I would like to leave you with four thoughts which we believe are fundamental issues to the long-term success of the potato business.

1. Potatoes are thought of as old fashioned, but convenience is changing this and increasing the per capita consumption.

2. Potatoes are thought of as high in calories and fattening. They are in fact low in calories and high in vitamin C, and are meaningful sources of vitamin B_6, folacin, niacin, vitamin B_1, phosphorus, magnesium, and iron. They are also a complex carbohydrate source.

3. Nutritional "restoration" of the processed forms of potatoes can continue to improve the role of potatoes in the world of nutritious and convenient foods.

4. The future of the potato must rest on quality at reasonable prices and an understanding of the true nutritional value that potatoes represent.

REPORT ON THE NORTH CENTRAL MARKETING PROJECT NCM—45

FACTORS AFFECTING POST HARVEST MARKET QUALITY OF PROCESSED POTATOES

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Project NCM-45, Factors Affecting Post Harvest Market Quality of Processed Potatoes, was approved in the fall of 1967 as a regional marketing project. However, the background for the present potato processing laboratory should be explained before the development of NCM-45 is presented.

In the early 1960's, the potato growers of the Red River Valley recognized that their future lay in developing the technology to grow and store potatoes for processing purposes.

The growers approached the experiment stations of the States of North Dakota and Minnesota for their reaction to the idea of the establishment of a processing laboratory. The stations agreed that the idea was excellent and the procedure was set up to obtain funds for the laboratory.

Much of the groundwork for securing funds was done by the Red River Valley Potato Growers' Association. Bills concerning funding of the laboratory were presented by the growers to both the North Dakota and Minnesota legislatures in 1963. Mr. Lyle Currie, then Executive Secretary of the Potato Growers' Association, also appeared at a Senate hearing on the laboratory for the 1963 USDA appropriation bill. The results of all three actions were favorable, and the two States each appropriated an initial funding of $38,000 for the biennium. The USDA appropriation was to be $100,000 on the annual basis. The Growers' Association agreed to construct the processing laboratory, which was to be deeded to the U. S. Department of Agriculture.

In April 1963, a meeting by the four groups concerned was held at the Potato Growers' Association offices to finalize plans for the laboratory. The location was to be at East Grand Forks on Association land adjacent to their present headquarters. The building was to be of "steel-insulation-steel" type. The size was to be 108 x 105 feet with the pilot plant area 105 x 60 feet and the office-research laboratory area 105 x 48 feet.

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[1] A laboratory cooperatively operated by the Eastern Marketing and Nutrition Research Division, Agricultural Research Service, U. S. Department of Agriculture; Minnesota Agricultural Experiment Station; North Dakota Agricultural Experiment Station; and the Red River Valley Potato Growers' Association.

In early June 1963, a memorandum of understanding was drawn up between the experiment stations of North Dakota and Minnesota, the Red River Valley Potato Growers' Association, and the Agricultural Research Service of the Department of Agriculture represented by the Eastern Utilization Research and Development Division. This document indicated the specific duties and details for each cooperator, and this was followed by a section on mutual agreement by the group. (At this time, it was announced that building bids were slated for opening on October 1, 1963, and occupancy by March 1, 1964, was considered possible.) Both experiment stations agreed to hire and pay salaries for scientists or assistants necessary to do their work. The USDA was to designate a leader agreeable to all who was to participate in the planning and to coordinate and supervise all phases of the program of the Potato Processing Laboratory. Mr. Roy Shaw was appointed director of the processing laboratory.

The laboratory was dedicated on November 19, 1964, and formally deeded to the USDA. The highlight emphasized was the cooperative nature of this undertaking.

The philosophy of the regional project system is that any two or more States interested in a similar area of research may submit a project covering the area of research in question. Since the work being done by the Potato Processing Laboratory was an excellent example of cooperative research, it was decided to develop a regional marketing project that would encompass other States in the North Central Region doing work of a similar nature.

Consequently, the representatives from the North Dakota and Minnesota Experiment Station and the Potato Processing Laboratory drew up and submitted a syllabus for a North Central Regional Research Project in March of 1967. This syllabus was approved by the North Central Regional Research Committee and the North Central Directors. As a result of this approval, NCT-92 (North Central Technical Committee) Potato Processing was founded, and Director A. G. Hazen of the North Dakota Agricultural Experiment Station was appointed Administrative Advisor for the group. Director Hazen stated in a letter organizing the Committee for development of a regional project outline:

> It is my thought that our cooperative undertaking at the East Grand Forks location can be further strengthened, not only at that location but also at each of the Experiment Stations currently involved in the cooperative agreement. Other stations might also mutually profit from a regional project.

E. P. Lana, North Dakota; R. E. Nylund, Minnesota; and Roy Shaw, Processing Laboratory Director, were selected to write up a preliminary outline for a

Regional Project. States indicating interest at this time in the processing project in the North Central Region were Indiana, Iowa, Michigan, Minnesota, Nebraska, North Dakota, Ohio, and Wisconsin. Final approval on the project was given by the Cooperative State Research Service, USDA, in November 1967. Because the approved project outline was circulated to all regions, four additional States--Alaska, New York, Florida, and Colorado--also expressed interest in the general scope of the research area.

The title of the project is "Factors Affecting Post-Harvest Market Quality of Processed Potatoes." The States presently using Regional Research Marketing Funds are North Dakota, New York, Michigan, Indiana, and Nebraska. States having contributing projects but with operating funds other than R.R.F. are Minnesota, Wisconsin, Illinois, Ohio, and Alaska. The USDA, through the Processing Laboratory, is also contributing financially.

The objectives of the project are:

1. To identify and quantify postharvest conditions which affect the processing quality of potatoes and to devise methods for more accurate prediction of the storage and processing quality of the raw potato.

2. To develop and apply process technology to produce new and improved potato products.

Minnesota, North Dakota, and the USDA provide personnel and equipment for the Red River Valley Potato Processing Laboratory. This insures regional planning because of the physical proximity of the personnel involved. Additionally, such states as Alaska, Colorado, Florida, Illinois, Indiana, New York, Ohio, Wisconsin, Michigan, and Nebraska may contribute to the work at the Laboratory by furnishing (under other project financing) raw potatoes produced under various climatic, soil, and other environmental conditions.

Exhaustive tests and analyses are conducted to identify the gene-environment interactions in the various varieties and lines of potatoes now available which cause differences in storage and processing quality of the raw potato. In addition, physiological studies and raw-product analysis should lead to improved handling and storage practices for existing varieties. Specific studies include:

1. The enzyme systems responsible for carbohydrate transformations in the potato (Indiana, Minnesota, Nebraska, New York, North Dakota River Valley Potato Processing Laboratory).

2. Free amino acids, sugars, phenols and nucleic acid metabolism in relation to chipping quality (Florida, Indiana, New York, Ohio).

3. Physiological preconditioning of potatoes to improve quality of potatoes for processing. The influence of such preconditioning on chemical composition will be determined (Colorado, Florida, Minnesota, North Dakota, Red River Valley Potato Processing Laboratory).

4. Gene-environment interactions during storage of present varieties and stocks (Minnesota, Nebraska, North Dakota).

The Red River Valley Potato Processing Laboratory has excellent pilot plant facilities for making potato chips, potato flakes, dehydrated pieces, and frozen french-fried potatoes. It also has the capacity and potential for developing and fabricating additional equipment for other processed potato products. As more information becomes available concerning the chemical and physical properties of the raw potatoes, the avenues will be opened to develop new and improved potato products. The Technical Committee of this project will be in an excellent position to insure the regional application of the findings.

Presently, 11 people are staffing the Processing Laboratory--5, including the director, under the employ of the USDA, 3 employed by Minnesota, and 3 by North Dakota. Equipment is purchased for optimum research and may be financed by any of the three organizations. Contributing States are free to send samples of potatoes to the Processing Laboratory for evaluation.

The first meeting of the NCM-45 Technical Committee was held at the Red River Valley Potato Processing Laboratory on October 22, 1968. It was primarily organizational and was attended by representatives of Alaska, Minnesota, Nebraska, New York, North Dakota, Ohio, Wisconsin Cooperative State Research Service, and the Agricultural Research Service.

The 1969 and 1970 meetings were also held at the Red River Valley Potato Processing Laboratory. These one-day meetings were primarily for research reporting and discussion. In attendance at either or both meetings were representatives of Alaska, Indiana, Michigan, Minnesota, Nebraska, New York, North Dakota, Ohio, Wisconsin Cooperative State Research Service, and the Agricultural Research Service.

Progress over the three years might well be illustrated by the changes in funding by the cooperators, as shown in table 1, as well as by publications and annual progress reports.

Varieties

Johansen *et al*. (*6*) released Norchip, which has very good chipping characteristics and yield and solids which are equal to, or better than, several standard chip varieties. Since its release in 1969, Norchip has become the fifth ranking variety in the United States for seed production. Johansen *et al*. (*7*) also released Norchief, a high-solids, red-skinned variety.

O'Keefe (*17*) released Shurchip, a slightly russetted potato of excellent chipping quality. Its specific gravity and yields are equal to, or better than, the standard chipping varieties. O'Keefe (*18*) also released Sioux, a good-yielding, high-specific-gravity red variety with good chipping qualities.

O'Keefe (*15*, *16*) developed a Mini-Chipper for testing for chippability, and he used this to evaluate chipping characteristics of many selections. Shaw and Turnquist (*32*, *33*) evaluated advanced selections by the

TABLE 1.--Funds for project NCM-45, Factors Affecting Postharvest Market Quality of Potatoes for Processing, fiscal 1968 through 1971

A. States with funded projects:

1968 Expenditures	
(North Dakota)	$ 5,054
(Potato Processing Laboratory, EMN, ARS-USDA)	100,000
1969 Expenditures	
(Indiana, Michigan, North Dakota)	31,082
(Potato Processing Laboratory, EMN, ARS-USDA)	100,000
1970 Allotments	
(Indiana, Michigan, New York, North Dakota)	46,932
(Potato Processing Laboratory, EMN, ARS-USDA)	100,000
1971 Allotments	
(Indiana, Michigan, Nebraska, New York, North Dakota)	101,600
(Potato Processing Laboratory, EMN, ARS-USDA)	100,000

B. States with contributing projects, but using funds of other sources:

(Alaska, Minnesota, Ohio, Wisconsin)

C. States without contributing projects, but still interested in NCM-45:

(Colorado, Florida, Illinois)

use of the Standard Chip Cooker developed at the Potato Processing Laboratory.

Lauer and Shaw (12) developed a source (S. Phureja x USW1) of genetic material yielding seedlings that will chip out of 40° F. storage. Pope et al (19) will report on processing characteristics of high solids S. Tuberosum- S. Stoloniferm hybrids.

Specific gravity readings ranged from 1.048 to 1.087 on 263 Alaskan grown clones from Maine and Beltsville breeding and selection work (11). Kennebec and Clone 90 were 1.083 and 1.099, respectively.

Gould (3) studied 12 varieties grown in various locations in Ohio over a 5-year span. He concluded that potato varieties for processing must be evaluated from more than one producer and over three or more years. Further, evaluation before and after storage is important if the product is to be processed, at least for chips, after storage. Specific gravity is a good indicator of yield and Agtron color is a more reliable index than Coughlin color.

Schoenemann (27) evaluated adaptability of 11 varieties grown in four locations in Wisconsin. On the basis of test data, he made tentative variety recommendations to Wisconsin producers.

Horticulture

Nelson and Nylund (13) studied the effects of vine kill on the yield and quality of potatoes in the Red River Valley.

Sodium arsenite at 9 lb., DNBP at 2.5 lb., Diquat at 1 lb., Paraquat at 0.5 lb. and 1 lb., and Prep at 2 lb. and 4 lb./acre were tested as vine killers for potatoes during 1963, 1964, and 1965. Based on ratings 1 or 2 days after spraying, 1 lb. Diquat, 1 lb. Paraquat, and 2.5 lb. DNBP/acre resulted in the quickest kill. Paraquat at 0.5 lb. and sodium arsenite at 9 lb./acre were slightly slower. Prep at 2 lb. and 4 lb./acre was consistently slowest. Some of the slower acting chemicals gave equally good kill after 7 days.

Chemical vine killing usually reduced yields and specific gravity by shortening the growing period. There was no effect from any of the chemicals on the color of potato chips. A slight amount of vascular discoloration did occur in tubers from all treatments. Vascular discoloration of tubers from vines treated with Prep at 2 lb./acre was greater than that of tubers from vines which were cut and not sprayed. None of the vascular discoloration was severe enough to be economically important.

In a second test, sodium arsenite at 9 lb. and Diquat at 0.5, 1, and 2 lb./acre were applied as single and split applications in 1963. The major effect from the split applications was a slower rate of vine kill.

Studies on the effect of herbicides, pesticides, and growth retardants have been made. Except for pesticides, no effect on chip color has been noted. Mist irrigation studies (26) showed that chips made from tubers from misted plots had poorer color than those from unmisted plots, both at harvest and after reconditioning following three months of storage. The relationship between size of tuber, time of planting, time of harvest, and tuber location in the hill on the type and quantity of sugar present in the tuber showed that levels of the different sugars varied with all the factors studied (10). Maleic hydrazide (10) did not modify a clone's chipping characteristics even though sprout inhibition was satisfactory. The effects of systemic disease (virus) on quality is under investigation.

Physiology

A major effort was made to determine physiological factors that affect storage and processing quality, and to develop criteria for predicting storage and processing quality.

O'Keefe (14) measured pH and storage temperature. At harvest, pH was 5.2-5.4. After 4 weeks at 40° F., pH climbed to 6.0-6.2. This 40° storage was followed by 7 weeks at 70° and pH dropped back to 5.4-5.6. Whether changes in pH preceded or followed changes in sugars is not known.

The initial work of Pressey (20, 23) on potato invertase and potato invertase inhibitor was followed by Ewing and McAdoo (2) on the nature of the invertase-inhibitor complex.

Methods for measurement of invertase and a naturally occurring inhibitor of invertase in potato tubers have been evaluated by Ewing and McAdoo (2). It was shown that graphical methods used by several groups of workers are inappropriate. Selective destruction of inhibitor through foaming was successful if accomplished by bubbling N_2 through extracts, but not by published methods of stirring in a blender.

Pressey (21, 22) studied sucrose synthase in developing tubers and the levels of sucrose synthase and sucrose phosphate synthase in stored tubers. He concluded that sucrose phosphate synthase may be important in sugar transformation in stored tuber, but that sucrose synthase was very low and probably not important. However, the levels of sucrose synthase was high in developing tubers and dropped to a very low level at a time when potatoes reached maturity. He felt that this enzyme had the possibility for a "physiological index of maturity." Sowokinos (34) made a careful study of the levels of sucrose synthase, protein and sugars from initiation of tubers in early July through harvest in early October. The correlation between tuber weight and sucrose synthase was very good.

Galactinol was isolated and identified (24).

Rios *et al*. (25) used the meadow vole (Microtus Pennsylvanicus) to establish nutritional value of potato flakes. With methionine supplementation (.066 gm./100 gm. potato flakes), the weight gains were 0.5-2.6 gm., whereas casein diets were 1.1-1.6 gm.

Gould and Deppen (4) followed the levels of fructose, glucose, sucrose, tartaric acid, citric acid, malic acid in Monona, Sebago, Red LaSoda at 50-45-40-32° F. Total sugars and total acid increased 3-4 fold as temperature decreased from 50° to 32° F.

Hasegawa *et al.* (5) isolated chlorogenic acid from two varieties of potatoes by column chromatographic methods and identified it by paper chromatography and by ultraviolet and infrared absorption spectral analyses. Chlorogenic acid was the principal phenolic compound of the inner tissue of tubers and the only compound which increased significantly during the storage of the potatoes at 40° F. No increase in the chlorogenic acid content was observed, however, in potatoes stored at 60° F. It was postulated that the increase in chlorogenic acid during cold storage is due to the accumulation of sugars.

Analytical

Shaw (29) developed a procedure for determining sugars in potato tubers by gas chromatography. Juice from tubers is extracted, boiled, and centrifuged, and the TMS (ortho-trimethylsilyl ethers) derivatives of the sugars are prepared. Column choice and operating conditions are given. Results are fairly comparable to those from wet analysis, are more comprehensive, and are more easily obtained. Shaw (28) extended this by inclusion of radioisotopes to follow carbohydrate transformation in stored tubers.

Ewing (1) reexamined the graphical determination of relative concentrations of enzyme and endogenous inhibitors. He points out the limitations of such approaches specifically in the case of potato tuber invertase and its endogenous inhibitor.

Wang *et al.* (35) developed a bisolvent procedure for potato glycoalkaloids. The glycoalkaloid isolated from the potato varieties was resolved into α-solanine and α-chaconine by thin-layer chromatography. The glycoalkaloid was concentrated in the cortical area of the potato and the ratio between the cortical area and entire potato ranged from 5-10 to 1.

A procedure for evaluation of potato protein by amino acid analysis and dye binding properties was developed by Kaldy (8).

Processing

Shaw and Lukes (30) found that potato chips fried at a high temperature (350° F.) have a lower oil content than chips fried at 300° F. The lower viscosity of the hotter oil favors more complete drainage of oil from the finished chip. By one or more treatments, chip temperature is increased after the chip emerges from the frier, resulting in a significant reduction in oil content. Flexibility of operation is improved, and economic savings may be realized in potato chip plants where oil costs per pound exceed potato solids costs per pound and in plants where reducing sugars cause use of lower frying temperatures. Less variability in oil content of product and greater plant throughput may also result.

Shaw and Shuey (31) worked out a tentative procedure to produce potato starch without waste. They used fine grinding and air classification of dehydrated potatoes with sieving and minimum washing to produce potato starch. A substantial reduction in the amount of waste water over that required by conventional washing techniques was obtained. The process proposed would reduce wastes by 90 percent.

Conclusions

Work under NCM-45 has progressed satisfactorily, as evidenced by increased participation and financing by the interested States and by the published work.

Fundamental breeding, several new varieties, and considerable study on variety-location interaction were reported. Some activity on horticultural practices is covered in a paper.

Basic plant physiology, particularly the study of carbohydrate enzymes and a possible index of maturity, makes interesting reading. We also know something about relationship of tuber pH, chlorogenic acid and total acids to tuber temperature. We also know the efficiency of potato protein is very good, especially when fortified with added methionine.

New procedures for measuring potato components such as sugars, enzyme inhibitors, glycoalkaloids and proteins were developed.

On processing only a little has been done--a procedure for reducing oil content of potato chips and a tentative procedure for production of potato starch without waste.

It would appear that NCM-45, Factors Affecting Postharvest Market Quality of Processed Potatoes, is an aggressively active project.

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INNOVATIVE METHODS OF INSECT CONTROL

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Such remarkable progress has been made by entomologists in developing methods of controlling the insects which attack crop plants that few of these pests cannot now be controlled by one or more techniques. However, no single method appears to solve all problems with pest insects or even the problems with a single insect in all circumstances. Conventional chemicals, sterility, biological agents, attractants, repellents, varietal resistance, and cultural, physical, and mechanical techniques are all useful and effective weapons, but maximum efficiency often can only be achieved by combining two or more of these methods in a logical and efficient manner, a combination usually termed integrated control.

The present era of insect control with synthetic chemicals began during World War II. It has resulted in inestimable benefits to mankind. However, entomologists recognized that this method had disadvantages--insect resistance, effect on nontarget organisms, residues, high cost of control, and continued agricultural losses, and their concern stimulated them to develop more fundamental approaches to insect control based on ecological knowledge of the particular pest insect.

Ecological approaches to insect control are based on the fundamental concept that pest management is to be achieved by applying restrictive pressure to an entire population of the insect or a large segment of it, as opposed to the application of conventional chemical methods to small, local segments of the population. Consequently, the most detailed biological and ecological information concerning the complex agroecosystem is required because in this system, a diversity of crops, climatic conditions, and ecological and biological entities exist that interact to affect the population dynamics of the pest species. Therefore, as need for alternative methods of insect control became more apparent, the entomological research of ARS was reoriented to obtain the necessary information. As a result, since about 1955, the Entomology Research Division has been redirecting its program until, at the present time, approximately 84 percent of its resources are committed to developing alternative methods of control and to fundamental entomological research (16). The estimated current allocation of resources is shown in Table 1.

Insects become pests when they do sufficient damage to cause economic loss. This is when the numbers of those doing the damage is so high that the plant is killed, its development is delayed, or the desired part of the plant is so damaged that it is not usable. Many factors affects the ability of pests to develop large populations. For example, the reproductive capacity of some species is so great that the adult females may each lay several hundred eggs, TABLE 1.--Current allocation of resources of the Entomology Research Division, ARS, USDA

Work area	Percent of resources	
Chemical control, total		16
Alternative methods		
Biology	14	
Sterility	12	
Plant resistance	7	
Cultural and mechanical	4	
Attractants	14	
Total		51
Fundamental Entomology		
Basic biology	19	
Metabolism	2	
Taxonomy	6	
Insect vectors	2	
Apiculture	4	
Total		33
		100

so populations can increase as much as 5-fold or more in a generation which lasts only 2-3 weeks. Or the numbers of a species present may fluctuate because of seasonal and weather conditions, food supply, and the presence of natural enemies and diseases.

If an insect or a mite species is adapted to an area, the most important factor regulating populations, and thus preventing the development of damaging numbers, is the presence of natural enemies (parasites, predators, and pathogens). Less than 2 percent of known insects are pests, and many of the other 98 percent are parasites and predators. In addition, over a thousand viruses, bacteria, fungi, rickettsia, and nematodes are currently known to attack insects in their environment. The populations of all these natural enemies of pest insects increase or decrease with the fluctuations of pests in the population so they maintain the pest populations within quantitative limits. As a result, in nature, the density of a given insect tends to stabilize them at what scientists term the species equilibrium position. However, this species equilibrium may be stabilized at a level that allows economic damage. Then supplementary control is necessary. Those species that are stabilized at a level that does not cause economic damage are seldom recognized as pests. The concept is basic to the development and application of insect control methods.

The one objective of any efficient system of insect control is therefore to take advantage of the natural regulators and to apply supplementary control when necessary without affecting other components of the ecosystem.

Cultural and Chemical Control

For the forseeable future, insecticides will continue to be important in the production of crops, and at present, they are the first line of defense against most economically important insect species. Thus, research is urgently needed to find new less hazardous insecticides, new and improved patterns of use, new formulations, and new methods of application. Also, effective and efficient control of insects with chemicals must be based on detailed and fundamental knowledge concerning the identity, life history, behavior, and ecology of that insect.

For example, one of the most important insect pests of potatoes in the United States is the green peach aphid, *Myzus persicae* (Sulzer), which causes damage by its feeding and also transmits plant viruses. In temperate areas, the insect overwinters in the egg stage on *Prunus* species. These eggs hatch in spring to produce 1 or 2 generations of mostly wingless aphids. Then beginning about the 3rd generation, winged migrant forms are produced that fly to secondary hosts such as weeds and commercial crops. Thus, peach trees and other *Prunus* trees in areas where potatoes, sugarbeets, and other hosts grow are an annual source of the insect. In addition, where winters are warm, the green peach aphids may live year round on many species of annual plants, and in intermediate climates, overwintering is accomplished both ways, which greatly increases the source of and magnitude of the spring population of the aphid.

ARS entomologists have therefore been investigating the green peach aphid in the large and complex agroecosystem of Washington State where many crops, insects, and ecological situations must be considered before it will be possible to develop an effective and efficient system of pest management. In some areas of Washington, several commercial crops are grown that are aphid hosts and also subject to the virus diseases they carry.

In the Yakima Valley, more than 8,000 acres of potatoes and about 3,000 acres of sugarbeets are grown in close proximity to 6,000 acres of peach orchards. Thus, the egg stage of the green peach aphid overwinters on the peach trees, and in addition the summer form overwinters in certain protected areas. Intensive ecological studies revealed that the warm spring-fed drainage ditches in the area produced a microclimate 20-50° F. warmer than the surrounding environment in which weeds, green peach aphids, and other insects flourished throughout the year. Then in the spring, these migrant aphids, once airborne, were carried in any direction depending on the prevailing winds. Suppression of this aphid was therefore attempted during January, February, and March 1965-1967, by burning the vegetation in the ditches in 22- and 30-square-mile areas before the migrating populations developed. As a result, populations of aphids in nearby sugarbeet fields were reduced over 90 percent (41). In other words, one source of green peach aphids could be eliminated by using a nonchemical technique.

In a completely independent study in the Columbia Basin of Washington State, an attempt was made to control the peach aphid on its overwintering host, peach trees, because both the populations of the aphid and the incidence of potato leaf roll disease were increasing with the increase of peach trees in the area. [Powell (28) estimated that 3,000 to 30,000 eggs of the green peach aphid may overwinter on a single peach tree, depending on the fall population of aphids and the size of the tree.] It was postulated that the application of an effective aphicide (29) to all the peach trees in a large area where these trees were the only source of populations of green peach aphid should reduce the populations and thus the incidence of disease. A survey was therefore made over a 275-square-mile area, and the more than 5,500 peach trees which were found were treated with an aphicide early in the spring of 1966, 1967, and 1968, usually between March 20 and May 5. Counts of winged aphids collected in trap pans were made twice a week after the beginning of the program and compared with similar collections made in 1965 before the program began. In addition, weekly counts of aphids were made on potatoes in fields located within the experimental area and compared with similar counts made in the 2 years before the start of the experiment.

In 1965, the year before the beginning of the test, populations of winged green peach aphids peaked at about 500 aphids per pan. In the first year of the program, 1966, and each year thereafter, the size of these peak populations was markedly reduced to 2 to 50 per pan. Also, the peak populations developed 3-4 weeks later than in 1965. Similar reductions were observed in the populations developing on potatoes. In addition, samples of potato tubers were taken from each field where counts of aphids were made. These samples were examined for the occurrence of net necrosis--a condition that during storage may develop in potatoes from plants infected with leaf roll disease, which is transmitted by the green peach aphid. For the 3 years before the beginning of the program, net necrosis occurred in 10 to 20 percent of the tubers examined. In 1967, 2 years after the program began, net necrosis occurred in 1 percent of the potatoes. Also in 1967, only 5 percent of the plants from replanted seed pieces had symptoms of leaf roll disease compared with 32 to 52 percent in the 4 years before the beginning of the program (Powell *et al.*, personal communications). The full and complete evaluation of this study is still to be presented. However, the preliminary data are exciting and demonstrate the potential of conventional chemical control used when the population of the insect vector is most vulnerable and has not yet migrated to the host crop.

Also, in northeastern Maine, the green peach aphid has only one recognized primary host, Canada plum, *Prunus nigra* Ait., (33). Research was therefore begun in 1967 to determine the feasibility of suppressing the aphid population to reduce the incidence of potato leaf roll virus by eliminating this host. A circular 315-square-mile area containing 85,000 acres of potatoes was selected as the test area, and thickets of plum were destroyed as located. The effects on populations of aphids are now being determined by monitoring populations of flying green peach aphids and populations on potato plants and by measuring the incidence of leaf roll disease. The preliminary results indicate that the program is effective. However, not all the Canada plum have been located, so the monitoring program will have to be continued for several years before the results of the program can be adequately assessed.

Resistant Plants

Among the most satisfactory methods of preventing damage to plants is the development of varieties resistant to insect attack. Painter (27) characterized the causes of plant resistance broadly as follows:

1. Preference and nonpreference

   Plants may not be acceptable to insects for oviposition, food, or shelter because of color, odor, lack of chemical or physical stimuli, and/or other similar factors.

2. Antibiosis

   Plants may have an adverse effect on the biology of the insect, and in some cases feeding on them may result in death of the insect.

3. Tolerance

   Plants may be tolerant to insect attack and sustain numbers that would severely impair or kill more susceptible types.

One of these mechanisms, or a combination, exists in many plants to make them resistant to attack.

Outstanding advances have been made in developing varieties of wheat resistant to the Hessian fly, Mayetiola destructor (Say), and the wheat stem sawfly, Cephus cinctus (Norton); varieties of alfalfa resistant to the spotted alfalfa aphid, Therioaphis maculata (Buckton); and varieties of corn resistant to the European corn borer, Ostrinia nubilalis (Hübner) (24). For example, at least 23 resistant varieties of wheat are now available to the farmer; as a result, the Hessian fly, which once caused high economic losses in the United States, today causes only minimal losses. Similarly, the dramatic discovery of a solid stem wheat variety that was resistant to wheat stem sawflies has saved wheat farmers an estimated $4 million annually.

However, the incorporation of insect resistant germ plasm into desirable varieties of horticultural vegetables is in its infancy. Stoner (40), as late as 1970, stated that to his knowledge only one variety of only one vegetable, the potato variety "Sequoia," has been released in which insect resistance is a major feature. Therefore, potential sources of resistant germ plasm have been reported for a number of other important potato insects such as the Colorado potato beetle, Leptinotarsa decemlineata (Say); the potato aphid, Macrosiphum euphorbiae (Thomas); the potato leafhopper, Empoasca fabae (Harris); the potato flea beetle, Epitrix cucumeris (Harris); the green peach aphid; and wireworms, Conoderus sp.

Moreover, even when the level of insect resistance found in commercially useful varieties of vegetables is not adequate to prevent economic damage, the resistance may still be useful: it can reduce the frequency of application and the amount of chemicals required to produce adequate control. This, in turn, reduces costs of production and pollution and may have a sparing effect on parasites and predators.

Thus, the development of plants that are resistant to insect attack is a challenging and new area of study. Potential sources exist throughout nature and need only to be discovered, identified, and used to solve many serious pest problems.

Biological Control

Control of agricultural pests by parasites and predators has had some marked successes (8) through introduction, conservation, or mass rearing of beneficial organisms. The introduction of beneficial insect parsites and predators for insect control involves exploration, introduction, evaluation, distribution, and establishment of the introduced insects which then become part of the environment and contribute to the control of destructive insect pests. In the United States, attempts have been made to introduce parasites and predators to control about 80 pests over a span of more than 80 years (7, 10). Of about 520 species that have been imported, 115 have become established, and 20 have provided important control of some of our worst pests. Also, introductions of beneficial insects have proved useful against the Rhodesgrass scale, Antonina graminis (Maskell), and several other scale insects, the European corn borer, the gypsy moth, Porthetria dispar (L.), and the alfalfa weevil, Hypera postica (Gyllenhal). However, introduced parasites of the potato aphid from France and India have apparently not become established in northeastern Maine (35) though this failure does not mean that continued efforts to find effective, efficient parasites will not be successful.

Another way to use biological control is to protect the native beneficial insects that play such an important role in regulating destructive pest populations. Researchers in Maine have recorded about 40 species of parasites from aphids infesting potatoes over a period of 24 years (35). None have been identified as contributing significantly to a reduction in populations of aphids, and further detailed studies may reveal a method of manipulating, protecting, or augmenting these populations of parasites to achieve this goal. Thus, studies are being continued to find doses of insecticides, formulations, sites for best application of materials, and other methods of application that will protect and conserve these natural enemies and make effective use of both chemical and biological systems of insect control.

Another approach that deserves considerable attention is the mass rearing of insect parasites and predators so that sustained release of these beneficial insects can be made to supplement the native forms in the environment.

This approach is currently being investigated in the Blue Mountain area of Washington. Here large acreages of canning peas are grown and the pea aphid, *Acyrthosiphon pisum* (Harris), is a problem. This insect overwinters on alfalfa plants that are reservoirs of pea enation and pea streak viruses. In the spring the alate aphid migrates to peas, carrying the disease with it (9). In the spring of 1966, about 100 million braconid parasites, *Aphidius pulcher* Baker and *Aphidius smithi* Sharma and Subba Rao, were reared in portable polyethylene-covered greenhouses which were placed over dormant alfalfa in the winter to protect the plants from the weather and to force growth four to six weeks ahead of the unprotected alfalfa growing in the surrounding fields. These field nurseries were then stocked with laboratory-reared pea aphids and parasites. As the populations of parasites in the nurseries developed, the parasites were allowed to escape through temperature-controlled automatic roof vents (13). The results to date indicate that substantial control of pea aphids on alfalfa was obtained and that migrations to pea plantings were reduced. The possibility of controlling pea aphids by this method appears promising.

Another example of the potential of mass releases was demonstrated in field tests in which two mass releases totaling 292,000 eggs or larvae per acre of predatory aphid lions, *Chrysopa carnea* (Stephens) were as effective against the bollworm, *Heliothis zea* (Boddie), on cotton as the best available insecticides (30).

In the same way entomogenous fungi too may have considerable potential for controlling species of potato aphids in some areas (34). Studies from 1941 to 1962 in northeastern Maine revealed that several species of fungi were important in regulating aphid populations. However, weather and other ecological factors are of prime importance in the establishment and effectiveness of the fungi. Therefore, research is being continued to determine methods of mass culturing fungi for dissemination, the factors that cause aphid infection, and the feasibility of entomogenous fungi for economic control.

Other Insect Control Methods

In the United States, over 100 species of insects are potential threats to potato production (32). Some are generally distributed and are present in varying degrees of abundance each year. Others vary in importance from year to year in most areas or are a problem only in restricted areas. However, as farming methods change and insect problems change, other methods of insect control currently being investigated may have an application to potato insect control programs.

Sterility.--The use of induced sterility to control or eradicate insect populations is among the most significant recent contributions to economic entomology. The best known method, sterile insect releases, involves the sustained overflooding of native populations with sterile insects of the same species at densities that are high enough so that little probability exists of fertile native matings. The method was hypothesized as early as 1937 by Edward F. Knipling, of the Entomology Research Division, Agricultural Research Service, USDA, but it only became a scientific fact after many years of research. First, screwworm flies, *Cochliomyia hominivorax* (Coquerel), sterilized by irradiation with cobalt-60, and released at the rate of 800 per square mile on Curacao Island in the Netherlands Antilles in 1954 completely eradicated the native population within about 3 months after the first release (2). Subsequently, releases of sterile screwworms in Florida (The Southeast Screwworm Eradication Program) and in the Southwest were similarly successful (1, 20). These programs cost less than 10 million dollars, and the estimated savings to cattle growers in the area since then probably exceed 100 million dollars. Finally, in the Southwest, a similar program has been equally successful, though here the investment has been about 20 million dollars; livestock men estimate savings of as much as 400 million dollars.

A second method, chemical sterilization of insects, is now being investigated. Chemicals that have sterilizing effects on insects have been known for many years. However, interest in their potential in insect control programs was renewed when the screwworm eradication campaigns were successful and when La Brecque (23) found 3 alkylating agents that induced sterility in both sexes of house flies, *Musca domestica*(L.). If effective methods of using these sterilants can be developed, they might be used both to sterilize insects for mass releases and also to sterilize a native population.

Sterilizing native populations.--If chemical sterilants could be used to sterilize insects in a native population, the expense of mass rearing and of releases would be eliminated, and the sterilized insects would remain in the population to compete sexually with unsterilized native insects. This latter effect, a bonus, would further reduce the reproductive potential of the native population. For example, if an insecticide kills 90 of 100 insects of each sex in a population, 10 pairs remain to mate and produce the next generation. However, if a sterilizing agent renders 90 of 100 insects of each sex in a population incapable of reproduction, the 10 males that avoided the sterilant could have to compete for the 10 remaining females with the 90 sterilized males. We would expect only 1 fertile mating to result from this combination. Moreover, the sterilized population would compete in time and space in the insects' ecosystem (21). Thus, the use of chemosterilants with baits and attractants appears a promising method of inducing sterility in native insect populations.

Attractants.--Several insects respond positively to many chemical, biological, and physical stimuli. Entomologists have envisaged manipulating these behavioral responses to achieve economic control of pests through trapping and killing, luring and sterilizing, or disrupti behavior. The most potent and specific insect attractants appear at present to be the sex pheromones, and Jacobson (18) recently compiled a list showing that such pheromones have been demonstrated in more than 200 insect species. However, at present, we have completed the isolation, identification, and synthesizing of the sex pheromone of only a relatively few insects, one of the most recent being the cabbage looper, *Trichoplusia ni* (Hübner) (3). While the chemists were working to produce this synthetic pheromone, researchers were using living female cabbage looper moths to investigate ways of using the synthetic attractant when it was ready.

One of the first approaches was to use these living virgin female moths in conjunction with a trap equipped with a blacklight lamp which is known to attract and catch cabbage looper moths. When the two methods were combined to produce a baited trap, more male insects were captured in the baited traps than in traps equipped with either blacklight or virgin females alone (15). As a result, when the breakthrough in synthesis came, investigators were equipped to evaluate the potential of the synthetic pheromone in the field (43).

A 3,110-acre ranch near Red Rock, Arizona, 2,240 acres of which are in crops (annually about 1,000 acres planted to fall lettuce, 800 acres to spring lettuce, and 200 acres to cotton), was selected for the tests. The installation of blacklight traps baited with synthetic cabbage looper sex pheromone at the rate of about one trap unit per six acres of cultivated ground was completed in March 1966. To date, collections of female cabbage looper moths in a check area about nine miles away have been 14 times greater and catches of male cabbage loopers have been 30 times greater than in the control area. Also, though egg and larval counts have varied considerably, fewer eggs and larvae were found on lettuce in the trap area compared with the check area. Thus, the results appear promising though the intensive use of insecticides on lettuce on the ranch makes it impossible to evaluate the full impact of the baited traps.

Sex pheromones might also be used to prevent or inhibit orientation. For example, investigators studying the behavior of male insects after they have been stimulated by sex pheromones have observed an adaptation or attenuation of response. After such conditioning, the threshold concentration of pheromone necessary to induce further response is raised for a time, and cabbage looper males may not respond to a lower threshold concentration for several hours after (17, 36). Also, many investigators have suggested that if high enough concentrations of pheromone were maintained over large areas, females in nature could not contribute enough additional pheromone to cause orientation of the males to them and so would not be inseminated by them. For example, in the field, a concentration of 1 x 10-10 gm. per liter completely prevented orientation of male cabbage loopers to pheromone-emitting females (12).

Another possibility, the use of an attractant combined with a toxicant to provide low-cost control of a pest over a large area, was demonstrated when the oriental fruit fly, *Dacus dorsalis* (Hendel), was eradicated from the island of Rota (39). In this case, methyl eugenol, a powerful male attractant, was combined with 1 percent naled and impregnated on cane-fiber squares. The squares were then dropped from aircraft flying in flight lines about 5 miles apart, except in inhabited areas where bait stations were used. Daily monitoring with traps showed an immediate 93 percent reduction in fly populations. After 10 drops, no flies were captured, and none have been found during the 24 subsequent months of trapping and inspection of host fruits. Only 3.5 grams of toxicant per acre were required for the entire program.

Repellent techniques.--Although insecticides have brought great progress in insect control, these killing agents do not prevent viruliferous insects from infecting crop plants; such disease vectors must be killed almost instantly, before they can feed, or they must be prevented from feeding. However, numerous investigators have observed and reported the response of aphids to color and light (5, 25, 6). Also, Lester Wall, Reynolds Metal Co., Richmond, Va. (unpublished report), observed a repellent effect of aluminum foil on insects in 1949. Kring (22) reported that when unpainted aluminum pans were placed around yellow pantraps, aphids avoided the yellow pantraps. Smith (37) therefore began tests in 1963 at Beltsville, Md., to determine whether this response could be used to repel flying aphids and reduce the incidence of viral infections in crops.

In one test in 1965, 50 percent of the soil area of each field plot of bush squash was covered with sheet aluminum foil. Other plots were untreated or were sprayed with an effective aphicide. During a 3-day period of heavy aphid flight, aluminum sheets reduced the catch of aphids by more than 95 percent compared with the catch in the unmulched check plots and in the plots sprayed with an insecticide. Also, the number of infected plants in the mulched plots was greatly reduced for 6 to 7 weeks compared with the sprayed and untreated plots. The yields of squash in the mulched plots were 6 times greater (38).

In another test on Long Island, New York, mulches of reflective aluminum and also of white plastic reduced catches of winged aphids in yellow pantraps by more than 87 percent and decreased the spread of cucumber mosaic virus in gladiolus plantings (19). Other researchers who have used such mulches have reported reduction of lettuce mosaic in lettuce plots (14) and protection of roses from injury by flower thrips, Frankliniella tritici (Fitch) (26). Aluminum mulches have not been effective with all aphids on all crops (11, 31); however, reflective mulches with plastic or paper backing can be produced to a wide range of specifications, and growers of some commercial crops are trying them to warm the soil early and to achieve control of weeds and aphids.

Insect hormones.--Other research is being done to investigate hormones and hormonelike materials that disrupt insect development rather than cause immediate death. Molting hormones and their analogs can cause sterility in adult insects; juvenile hormones which interrupt insect development sometimes cause the production of monster insects that finally die, or if they attain adulthood, cannot reproduce because of their physical abnormalities (42). These hormonal materials would not be expected to have a detrimental effect on nontarget organisms, but they are effective against test insects at small doses of about 1 nanogram, that is, one billionth of a gram. Other "hybrid" synthetic ethers, which are juvenile-hormonelike materials, have been found to block normal insect growth and development, and these compounds, some of which are fairly easy to synthesize, often are more potent than the hormones produced by the insect or biologically similar synthetic compounds previously tested (4).

Summary

Research designed to develop and exploit alternative methods of insect control demands the most exacting and sophisticated information about insect biology, behavior, movement, ecology, and population dynamics. The focus of such research must be directed to an entire insect population or to a large segment of it since these methods are designed to suppress or reduce an insect population to a level below the economic threshold. Many insect species are capable of moving great distances; thus methods designed to reduce such populations in local or limited areas have little probability of success because insects migrating from great distances often prevent successful reductions of a total population.

In recent years, alternative methods of insect control have had a number of significant successes. However, no one method appears to be adequate to solve all insect problems or even, in many cases, the same insect problem in different ecological conditions. Often, a single method will not be successful, but a combination of methods that can be logically and effectively integrated may bring the maximum pressure against an insect population.

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EFFECTS OF HIGH-SPEED RECONSTITUTION PROCEDURES ON THE NUTRIENT VALUE OF INSTANT POTATOES

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Among consumers, one of the fastest growing demands is for convenience-type foods--precooked, frozen foods which are thawed and reheated quickly prior to being consumed. This increase in use is not limited to the individual consumer, but is also apparent in the case of institutional food service outlets. Little is known about the way the procedures used to prepare and reconstitute such foods affects their nutritional value.

The nutritional value of a food or food product may be altered by processing. In some cases, an increase in nutritional value results. In most foods, however, any changes observed are decreases. The latter are caused by destruction of the nutrient (e. g., vitamins) or by decreases in the nutritional availability of the nutrient (e. g., amino acids of proteins). Some of these changes can be monitored, directly or indirectly, and information obtained about the effects of processing on nutritive value. In collaboration with the Institute of Human Nutrition, Columbia University, such procedures are being used to determine the effects of using high-speed reconstitution techniques on the level and/or biological value of some selected nutrients in several "representative" food products.

One of the food products already investigated has been a potato product--instant mashed potatoes (potato flakes, dried nonfat milk, margarine). The effects of institutional-scale preparation procedures and of various treatments have been studied. The treatments have included holding the freshly prepared product at 180° C. for 1/2, 1 1/2, and 3 hours, and freezing the prepared product followed by reconstitution or reheating using a steamer, an infrared oven, a convection oven, or a microwave oven.

Levels of thiamine, riboflavin, and ascorbic acid were determined in the products subjected to each of the treatments. Likewise, to assess possible effects on protein nutritional value, Protein Efficiency Ratios, Shortened Pepsin Digest Residue Indexes, and chemical estimates of available lysine have been determined on freeze-dried samples.

The foods were prepared and processed, and the vitamin analyses done at Columbia University by C. Ang, A. E. Frey, and G. E. Livingston, while the work on estimating any effects on protein nutritional value was done at Beltsville by C. E. Bodwell, M. Womack, and S. Hagan. The results of these analyses have not been published.

In the case of possible effects on protein nutritional value, little change was observed for any of the treatments studied. For all the potato samples, the average, overall Protein Efficiency Ratio value was about 2.6 (using the potato products as the only source of protein with amino acids being added to give a balanced protein source). Values with casein as the protein source (similarly balanced with amino acids) were about 3.5. Among the potato samples from the various treatments, no apparent significant differences or trends between treatments were observed. Likewise, the values for the Shortened Pepsin Digest Residue Index only varied from 57 to 63 (compared to a value of 60 for casein). The average available lysine value was 340 mg./100 gm. of nitrogen with all values for the samples from the different treatments being within ±5 percent of this average value.

Thiamine and riboflavin were found to be marginally affected by some of the treatments (10-12 percent losses). Conversely, ascorbic acid was very labile to heat. In some cases, only 12 to 15 percent (of the ascorbic acid originally present in the nonprepared ingredients) was retained after preparation, freezing, and reconstitution. With reference to ascorbic acid content, some of the reconstitution procedures were much less destructive than others.

Whether similar observations to these will be obtained with other food products is not yet known. It is expected that at least some indication of damage to protein will be observed with some of the high-protein foods. In any case, however, the results on ascorbic acid in potatoes, and some of the results being obtained on other food products, strongly suggest that the effects on nutritive value be considered when selecting and using high-speed reconstitution procedures. Likewise, as previously suggested by J. B. Brown at this conference in 1959 (1), the effects on nutritional value should also be considered when developing new processing or preparation procedures.

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SHEAR PRESS DETERMINATIONS OF THE RAW PRODUCT AS A POSSIBLE TOOL FOR QUALITY MEASUREMENT OF POTATOES

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As processing of potatoes continues to expand, it is increasingly evident that more objective tools or parameters are needed for measuring internal quality of the raw product as affected by environmental, cultural, and storage treatments. At the present time, quality measurements are limited primarily to specific gravity determinations, sugar analysis, and subjective tests on cooked and fried products in the laboratory.

Shear press observations on raw tubers which have been reported in the literature are very limited. Lujan and Smith (2) obtained a negative correlation of -0.19 between shear force values of raw tubers cut into cubes and their specific gravity. Wiley and Stembridge (5) found a positive correlation of 0.93 between raw shear slice values of three apple varieties and their starch content. Previous studies by Wiley and Thompson (6) showed a positive correlation of 0.828 between firmness of canned apple slices and shear press readings of the raw slices. On the other hand, Sterling and Bettelheim (4) state that shear press measurement of raw potatoes measures strength of cell wall which they state is unrelated to potato texture. Ross and Porter (3) suggest that no shearing takes place on raw strips, but the tissue splits instead of being sheared. These studies were initiated to determine differences in shear force of raw potatoes and possibly relate these differences to texture of the processed product.

The studies were conducted on the Russet Burbank and Norgold varieties which were grown at the Othello, Wash., field station. Both varieties were planted April 23, 1970, in the same field with 350 lb. of triple 16 as N, P_2O_5 and K_2O, side dressed at planting time. When the tubers were approximately the size of golf balls, 15 hills of each variety were harvested twice a week during the growing season until the middle of October and records taken on average size increase, sugar changes, specific gravity, dry matter content, and texture development as measured by a shear press. Norgold vines were practically dead by the middle of September. Russet Burbank vines remained green until they were beat off September 20. Both varieties were harvested September 30 and placed in 48° F. storage. Approximately a month later they were separated into specific gravity groups with brine solutions in increments of 0.005. Some of the 1.090 group were placed in 34° F. and 45° F. storage. Shear force readings were made of the different groups at various times during the storage season. Samples of the specific gravity groups were taken to the Chef Reddy frozen french fry plant at Othello, Wash., where they were blanched, par fried, and frozen. A portion of the fries were finish fried in a pilot plant at Chef Reddy Foods, Inc., and texture ratings made on them by a Federal grade inspector. Remainder of the samples were brought to Pullman, finish fried in a deep fat fryer in small lots at 360° F. for 2 minutes, and shear force readings made within 3 minutes after removal from the fryer.

Shear force readings were made with a Food Technology Corporation model TP-1 texture press with a standard (10 blade) shear compression cell and direct reading (peak force) texture gauge. Fifteen to twenty uniformly sized tubers represented a sample. Each tuber was sliced longitudinally with a restaurant type french fry cutter with 3/8-inch grid. Six slices were taken out of the center portion of larger tubers and three slices out of small tubers. The long french fry slices were cut in two, about 1/8-inch of the ends were evenly cut at right angles to the length, apical and bud portions butted together and cut exactly 6.5 cm. in length with a special two-blade cutter. Three butted-together slices were placed in the cell at right angles to the grid for each reading. Thirty readings were made on each lot for the raw product evaluation. Small tubers used for study of texture development during growth were handled in the same manner except slices from two whole tubers were butted together to fill the width of the cell. Every effort was made to use uniformly sized tubers and the same portions of tubers from each sample. Finish fried slices were handled in the same manner for the texture readings.

After an initial slight decrease, as Russet Burbank tubers grew and developed, a definite progressive increase in shear force readings occurred. On the other hand, behavior of the Norgold variety was definitely different. A greater initial drop in shear force readings was experienced and the curve leveled out with no increase in readings with growth, as was experienced with the Russet Burbank. Any explanation of the initial drop in shear force readings for both Russet Burbank and Norgold would be a matter of conjecture. Possibly the numbers of cells congregated together when tubers are small may have had an effect. Within the same lot of potatoes harvested and stored together, as specific gravity increased for the Russet Burbank variety, a linear positive increase ($r = +0.942$ significant at 1 percent level) in shear force readings was obtained. However, the Norgold variety exhibited no positive shear force response to increase in specific gravity. If there was a response, it appeared to be negative ($r = -0.809$), which was not statistically significant. A seedling from the USDA breeding program at Prosser was included in the graph. Its response was somewhat similar to Russet Burbank.

Storage temperatures appear to have an effect on shear force readings. As can be seen in table 1, a statistically significant lower reading was obtained from tubers stored at 34° F. in comparison to 45° F. storage.

Cunningham, Zaehringer, and Le Tourneau (1) found that tissue of potatoes stored at 38° F. sloughed less than tissue stored at 45° F. or 52° F.

A very high correlation was obtained between shear force readings of the raw product (Russet Burbank) and readings of the finished fried product. The readings for the finished fries were, of course, much lower at each of the specific gravity groups. On the other hand, the correlation between raw product and finished fries in the Norgold Russet variety was very poor, primarily because raw shear readings did not increase with specific gravity of the tubers.

TABLE 1.--Shear force readings (lb. of force) as affected by storage temperature of tubers

Sampling date	Storage temperature	
	34° F. (1° C.)	45° F. (7° C.)
January 2, 1971	310	338
February 24, 1971	321	341
March 26, 1971	318	337
Mean	316*	339

*Significantly less at 5 percent level.

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OBJECTIVE MEASUREMENT OF TEXTURE VARIABLES IN RAW AND PROCESSED FRENCH-FRIED POTATOES

(Summary)

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Five of the most important variables encountered in frozen french fry quality studies are specific gravity, raw potato storage, raw potato firmness, methods of freezing the product, and the cooling of the hot french fry slices prior to the time they can be consumed. Part of the last year has been spent on attempts to obtain information as to the effect of some of these variables on shear force results. This information is necessary for the intelligent interpretation of shear force data obtained with unknown samples.

A shear force curve contains three definite changes in direction due to three different events which occur during the shearing. The first has been described as a disruption of the internal material without bursting the crust. If the shear blades are stopped soon enough, before complete disruption, the slice will return to the original shape. If allowed to continue, permanent indentations will result. The second peak results when the crust bursts due to the build-up of pressure of the inner contents held under increased stress inside the intact crust. When the crust bursts, the inner contents are expressed in a manner similar to the way toothpaste comes out of a tube. As the upper blades continue to descend, the upper crust is pushed down on the lower crust until it lays immediately on top. At this point the two crusts are sheared,and peak 3 results.

Many of the variables produce changes in one or more of these peaks, and these changes must be related to the variable in such a way as to be able to predict what will happen under certain conditions. For example, increased fry time increases the height of peak 3 as well as the area under the entire curve. Since blanching is part of the cooking, increased blanch time also increases these same parameters, but to a lesser degree because the temperature is lower. Peak 2 tends to be less prominent with overcooked samples due to the firming of the slice interior and to hardening of the outer surface. On cooling, these parameters decrease, but crust shear (peak 3) drops off more rapidly than does crust burst (peak 2). When cooled, under-processed slices produce a peak 3 which is lower than peak 2.

With frozen slices, longer oven reheating increases the second and third peaks. Frozen and reheated slices produce a peak 2 which is less prominent than that resulting from shearing freshly fried samples. When french-fry slices are frozen, the crusts undergo a structural alteration and, hence, are less firm after reheating than nonfrozen slices. Instead of bursting, the frozen crusts tear gradually and the peak 2 becomes less discernible. Refried slices have crusts more like freshly fried slices than those reheated in the oven. The more prominent the peak 2, the more appeal the slices have to the consumer.

Tubers, having specific gravities of 1.080 and 1.090, were employed to study the effect of specific gravity. Potatoes of specific gravity 1.090 always produced fried slice shear force values (peak 3) higher than those of specific gravity 1.080. This was also true of areas under the curve. Nonfrozen samples always demonstrated this result better than frozen samples. Upon cooling, after normal frying, the 1.080 slices decreased in texture quality more than the 1.090 slices.

Contrary to expectations, frozen and reheated slices did not give a much lower crust shear value (peak 3) than freshly fried slices. A lower peak 3 was expected because the slices tend to be less crisp and firm from a subjective standpoint. The difference, however, is only very slight. In frozen slices, the crust has been damaged by freezing and a lower peak 2 results, as discussed earlier; but further addition of force to the shearing phase of the operation produces almost the same value as obtained with freshly fried slices.

No major continuous decrease in shear parameters was observed during nine months of storage of the raw tubers. All tubers gained in specific gravity about 0.008 to 0.009 unit. This slight increase in solids apparently balanced any possible decrease in shear value which might have resulted from the fact that all tubers became less firm during the storage under our conditions.

One of the difficulties with evaluation of potato texture is the variation in firmness among tubers, even those with identical specific gravity values, and in the firmness within a single tuber. A series of experiments was carried out to attempt the measurement of the texture of individual morphological zones of tubers. For this work, a small, rapid reading, penetrometer-type instrument, called a Durometer, was used. Despite the small size of the truncated cone tip of the instrument, the individual zones (skin, cortex ring, xylum band, wide perimedullary band and small pith zone) could not be measured in a practical manner. Therefore, the potatoes were divided into six transverse sections and three concentric zones for comparison.

The outer zones have higher solids contents than do the inner zones, and they exhibit higher Durometer readings. Intermediate and inner zones differ, between themselves, only slightly. Outer cells are smaller, have smaller vacuoles and a higher percentage of cell wall material than inner cells; i.e., higher solids, which accounts for the direct relationship between Durometer and solids values.

Stem-end moisture contents are lower and Durometer readings are higher than bud-end values. Like outer cells, stem-end cells have a higher percentage of cell-wall material and less moisture than the newer and more tender bud-end cells. Once again, a direct relationship exists between Durometer readings and solids content.

In any one lot of potatoes, two subjective lots can usually be separated, namely, those which are most firm and those which are least firm. In these lots, an inverse relationship was demonstrated between Durometer readings and solids content. This is apparently due to the high-moisture-content, most-firm tubers. More turgid cells resist Durometer penetration to a greater extent. This we compare to a highly inflated basketball which resists penetration of the fingers more than does an underinflated ball. One exception to this relationship was noted. As the Durometer value curve slopes upward from bud-end to stem-end, there is a significant decrease in the slope of most firm tubers and an increase for least firm tubers at the center section. Loss of firmness, which usually increases with storage time, apparently develops at the ends of the raw tubers.

These penetrometer relationships and technique will be studied in the future in an attempt to correlate raw texture, as measured by this objective test, with the results obtained for french-fry texture as measured subjectively by a taste panel.

CIRCULAR CONFIGURATION AS A NEW CONCEPT FOR POTATO STORAGES

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The potato industry is a progressive and expanding one. Each year growers are producing larger volumes of potatoes. Many growers are combining their individual crops into huge cooperative storages in order to gain marketing leverage, trackside locations, and improved economics through better space and equipment utilization. With the continuing growth of the potato industry, more and more storage capacity is required.

The problem of gaining more storage capacity cannot be solved by increasing the depth at which the potatoes are piled in the bins, because of possible resulting damage to the quality of the potatoes. Neither can increasing bin lengths be an entirely acceptable solution, because of the design and operational problems that would result with the environmental control system. In attempts to gain additional capacity, many storage operators have constructed long, narrow facilities to accommodate more bins. As a result, some of the potatoes are 500-600 feet from their loading point. With such a design, handling huge volumes of potatoes each year is a problem.

One possible solution to the potato storage problem is offered through the concept of a circular layout. Among the several advantages offered by this design is more efficient materials handling.

Geometrically, the circle provides a maximum area within a minimum perimeter. When the large areas required for potato storages are considered, a circular design for the storage provides for more compactness and a much more efficient utilization of space than a square or rectangle.

Storage in this new design is arranged around a central work area from which interior walls extend, like spokes of a wheel, to separate the storage bins. This radial arrangement of the walls provides for bins that are identical in size and shape and equidistant from the central work area.

Capacities for circular storages range from 13,000 hundredweight (cwt.) at 25 feet of radius to 475,000 cwt. at 150 feet of radius. These capacities are based on 16 feet of pile depth and 42 pounds per cubic foot of bulk potatoes. When these factors remain constant, the only variable that would affect the capacity is the radius length. However, the effect on capacity of a change in the radius length is directly proportional to the square of the radius (r^2), and a change in the length of a short radius does not affect capacity as much as a change in the length of a long radius. This phenomenon is utilized in the design of the circular storage by locating the work area in the center of the layout, where the radii are short.

With present methods, potatoes going into storage flow rapidly into several bins from several sources, simultaneously, causing much activity and congestion of equipment in the filling area. Potatoes removed from storage for marketing flow from only one or two bins at a time, relatively slowly, to a single location, resulting in very little equipment and activity in the unloading area. The circular storage layout provides bin entrance and exit space according to need--a maximum of entrance space for filling activities and a minimum of exit space for emptying activities. In the yard area beyond the exit doors, adequate space is provided for maneuvering the trucks and equipment during filling operations; there is also extra space for an increasing number of these vehicles.

The location of all bins equidistant from the receiving point provides a very important advantage in that the handling system can be standardized. Several other advantages are gained as a result of the shorter distance from the receiving point. The distance the potatoes must be moved is minimized, which, in turn, greatly improves the efficiency of dry bulk scooping operations. When a wet handling system is used, the flumes can be shorter and shallower. In addition, booster pumps and large pipe systems are not required, because the bulk potatoes are close at hand.

The circular design is also very adaptable to the layout and design of washing and packing line operations. The diverging walls create a wedge-shaped area that expands laterally at a rate which fits the needs of most packing operations; the area is narrow where the initial washing equipment requires little lateral space, and is wider where the packing line progresses and operations require more space. One or several bin areas--or the central work area--may be utilized as packing areas. Washline and packing line operations might include expanding a wedge, or wedges, beyond the periphery of the circle in order to provide additional space, adding a second level to the facility, or constructing a completely separate packing facility.

The circular storage can accommodate both railroad cars and highway trucks for either inside or outside loading. Railroad tracks can be installed on a radius of the circle so that they will not cross the bin-filling area.

Every layout should allow for expansion of the facility. One way of allowing for expansion of a circular storage might be to construct only half of the building (semicircle) initially, and add the other half as production and marketing expansion dictate. Other possibilities might include adding more outer rings to increase storage space, or constructing completely separate structures.

The materials and techniques used to construct a circular storage would not be limited to those in most common usage; the design is adaptable to the use of prefabricated components and formed-in-place techniques. The basic circular concept is also adaptable to shapes such as domes, hemispheres, and cones.

FLUOROCARBON–LEACHING OF FRENCH–FRIED POTATOES

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Three of the most serious problems confronting the french-fry potato industry are: (1) the inability to lower the reducing sugar content to a level where potato strips finish-fry to a uniformly light color, (2) the inability to produce fries with a crispness and rigidity that lasts for several minutes after removal from the fry oil (long-potato-life), and (3) the inability to produce a high quality fry with a low oil content.

Attempts to solve these problems have led to extensive new variety breeding programs; to the application of foreign material such as gums, alginates, modified starches, and calcium chloride to coat the fries; and to the use of successive blanches and differing hot-air drying methods. One of the most effective procedures used at our laboratory both to increase rigidity and reduce oil content was the application of infrared irradiation to the strips following leaching and prior to par-frying. We have not, however, been able to develop a machine capable of uniformly turning large quantities of potato strips under the infrared lamps. These studies are being continued.

For some time we felt there had to be a better way to lower the reducing sugar content than by reconditioning or prolonged high temperature water leaching. Much loss of weight and development of rot occurs with prolonged reconditioning. When the water leaching is excessive and/or the leaching temperature is high, flavor compounds are removed with the sugar. Breeding programs designed to produce low reducing sugar varieties or varieties that recondition well are long-term projects, and often when certain desirable qualities are bred into a variety, other desirable qualities are lost and undesirable qualities appear. The major requirements we set for ourselves were that the procedure must be quick and reproducible; it must only affect the surface, but it must do so uniformly. Such a procedure has now been developed.

Plant physiologists have known for many years that one of the major effects of freeze damage to plants is a change in the permeability of the cell wall, resulting in a rapid leaking of cell contents during the thaw. We found that this principle could readily be applied to french fries by using a surface-freeze followed by a warm-water leach.

First we tried an air-blast freezer at approximately -36° F. for surface freezing. At least a 7-minute freeze time was needed to get a surface freeze. In most instances, this freeze was not uniform in depth over the whole strip, and we ended up with mottled finished fries following the water leach. Gaseous nitrogen cooled to -40° C. and to -70° C. gave similar results. Some varieties of potatoes taken from 40° to 45° F. storage never could be lightened, and most of the time all varieties with high sugar content had a mottled appearance. When frozen all the way through, the strips lightened, but not always uniformly, and when finish-fried, they had a soft mushy interior.

We felt the main problem, the inability to get uniform leaching with cold gases, was due to the uneven and slower rate of freezing than could be obtained by total immersion in liquid refrigerants. Experiments were then conducted using liquid nitrogen and dichlorodifluoromethane (R-12). Potato strips could be safely surface frozen up to 15 seconds with liquid nitrogen, but extending the time to 20 seconds caused the strip to shatter. Very often even 15 seconds freezing caused fine hair-checks on the surface which showed up on finish-frying as an undesirable "salt and pepper" appearance. When R-12 was used at -70° C., the strips had to be removed in 3-5 seconds. After 5 seconds, the strips shattered. However, when R-12 was used at its boiling point (approximately -30° C.), no hair-checking developed, and it could be frozen solid without shattering. R-12 also has the advantage of being recoverable; liquid nitrogen is not. We settled on the use of R-12 at its boiling point and conducted studies varying the time of immersion from 5 to 15 seconds. Thickness of the surface crust is directly associated with freeze depth and leach time. Usually with good quality high-solids potatoes, a freeze time of 7-10 seconds was sufficient to produce a surface crust.

Leaching is usually done commercially using water temperatures of 140° to 180° F. Commercial leaching procedures are now as numerous as processing plants. With our process, we settled on a water temperature of 120° to 125° F. as ideal. Temperatures as low as 65° F. gave good leaching, but the time in the bath was excessive for large commercial operations. Temperatures of 135° F. or above often gave mottled finished fries. We theorize that at the higher temperatures some protein coagulates and the starch gels. As a result, some of the openings in the cell wall in certain areas of the strips are sealed up, and movement of the sugars out of the cells is reduced. At 120° to 125° F., we never have trouble with mottling, and the rate of leaching is sufficiently fast for a commercial process. Usually 5-15 minutes are sufficient. Although leaching for 5 minutes may be enough to remove sugars, it is usually not sufficient to set up a good strong surface crust. Therefore, it is up to the processor to determine just what type of surface crust he wants, adjusting his freeze time and leach time to obtain it. It is easily controlled over a wide range of surface texture. Also, a somewhat thicker and more impervious surface crust reduces oil uptake during frying; and as oil uptake is reduced, production costs go down. For this reason, a longer leach time would usually be economically advantageous.

It must be emphasized that the treatment described in this paper is solely a surface treatment, and it does not overcome the mushy soft interior that is associated with low-solids or extremely high-sugar potatoes. When these types of potatoes are used, we can produce exploding fries. We theorize that there is not sufficient starch in the tubers to tie up all the free water present during retrogradation, and since the surface crust is quite impervious, steam pressure builds during finish-frying until a weak spot in the crust splits open. We have only found this condition to occur with very poor quality tubers. Even under conventional practices, however, such tubers cause serious problems. Usually the only way of making a decent product from these tubers by conventional methods is to lose additional water either by additional drying, by hot air, or by frying. Use of thinner slices, such as 1/4-inch or crinkle cuts, has almost eliminated the problem in our trials.

The potential for poor-quality tubers to explode in finish-frying when they have been given the surface treatment for sugar removal can be controlled in various ways. One way is to extend the par-fry time from the standard 45 to 60 seconds to 120 seconds. In this way, sufficient water is lost to prevent explosions from occurring. Of course this costs the processor, but at least the lot is saved and the danger to the fry cook is eliminated.

Another way to prevent explosions can be applied at the institution serving the fries. This may be the best way because in addition to overcoming defects caused by a poor quality product, it offers another advantage--preventing explosions. This is a double finish-fry method, first frying for 1 minute, holding the fries at room temperature for a few minutes to two or more hours, and then finish-frying for a period of 60-90 seconds, depending on the degree of crispness desired by the cook. This frying first for only 1 minute prevents explosions. If explosions are going to occur, they will happen between 75 and 105 seconds after the fries enter the oil at 370° F. During the time between the first frying and the finish-frying, the strips do not lose their rigid blocky shape, shrivel, get greasy, or turn dark. The use of a double fry, whether or not there is a danger of explosions, offers the institutional manager the chance to use some of his fry cooks at times other than the peak rush hours to perform the first fry and then get the advantage of a 60-90-second finish fry when needed. Also, the refried potato strips have an excellent flavor, increase very little in oil content, and are crisper than those given an uninterrupted finish fry.

This product has also performed very well for baking. The product was baked at 450° F. for 12-15 minutes from the frozen condition. The potato strips maintained their mealy baked potato internal texture and crisp surface crust. They were very close in quality to those finish-fried in oil, but had a lower oil content. It would appear this product may be a badly needed addition to the retail market.

Equipment to specifically perform this job has been designed and a small scale prototype has been built by an interested refrigeration company to demonstrate the workability of the process. Plans are now being finalized for a commercial installation.

In summary, the apparent advantages offered by this process are: (1) positive surface removal of reducing sugars, resulting in uniformly light finished fries; (2) better crispness; (3) permanent rigidity; (4) reduction in oil uptake by at least 25 percent; (5) no need for reconditioning; (6) standardized leaching procedures for all lots of potatoes; (7) complete and reproducible control of degree of surface texture by the processor; (8) final quick fry of 60-90 seconds by means of a double finish-frying; (9) a product that can be continuously refried; and (10) possibility of a good quality baked product.

SUBSTITUTION OF SODIUM HYDROXIDE BY POTASSIUM HYDROXIDE FOR PEELING POTATOES AND OTHER FRUITS AND VEGETABLES

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Lye (sodium hydroxide, caustic soda) peeling of potatoes and other fruits and vegetables is one of the major sources of waste production and water pollution in many food processing plants. Lye peeling is used extensively for peeling potatoes, sweet potatoes, tomatoes, beets, carrots, corn, pineapple, peaches, apricots, and pears. In Idaho until very recently most of the potatoes were peeled with lye except for plants producing dehydrated granules or flakes. The major environmental problem associated with potato processing is the large quantity of solid and liquid wastes produced from a typical plant. For any plants using lye peeling, the waste disposal problems are greatly increased because of the presence of sodium ion (Na+) in the waste or waste water.

The settleable solids from lye peeling can be recovered in the primary treatment of the waste and used as livestock feed. The dissolved solids and the Na+ remain as serious pollution problems. Secondary treatment will remove most of the organic soluble solids and is being performed in some cases now. If the Na+ were not present, the wastes from any of the waste treatment facilities could be sprayed on the land and used as irrigation water. In the presence of Na+, spraying should not be performed unless sandy soils are available. With silt or clay soils, the Na+ concentration can increase, causing the clay aggregates to disperse. This breaks down the soil aggregates with the result that water will not penetrate through the soil. Plants will not grow and the land is ruined for agricultural use.

Because of the bad effects of Na+ on the soil and probable restrictions on the amount of total salts which can be discharged into the rivers in the future, many processors are changing to either "dry caustic peeling" or steam peeling. Dry caustic peeling is a relatively new process in which potatoes, for example, are dipped in hot lye solution, drained, and then exposed to infrared radiation; the dried skin curls and is easily rubbed from the tubers. Steam peeling plants can spray irrigate their waste material effectively. However, steam peeling supposedly results in higher peeling losses than lye peeling, especially if many bruises or imperfections are present (3). The commercial dry peeling process (2) uses a combination of lye and infrared heating. This process requires much less water and a more concentrated solid waste is obtained. The presence of the Na^+ can raise formidable problems of waste disposal if livestock feeding is not possible or desired.

The main purpose of this research was to find an alternative to soda lye peeling of potatoes. The choice of potassium hydroxide (KOH) as a substitute for lye (NaOH) in these tests was based on the following:

1. Na and K compounds belong in the same group of the Periodic Table of elements and have similar chemical and physical properties.
2. For people on low-sodium diets, the use of potassium chloride (KCl) is sometimes recommended to replace sodium chloride (NaCl).
3. Olsen (5) in 1941 used both NaOH and KOH for peeling peaches. Preference was given to soda lye because of lower cost.

Substitution of soda lye by KOH would result in the following advantages:

1. Potassium or potash, a major plant nutrient, is substituted for a nonessential deleterious element. Potassium uptake by plants is second only to nitrogen uptake. Potassium is a required fertilizer in many nonarid soils.
2. The wastes from the processing plant as neutralized waste, or the solid or liquid from the primary or secondary treatment facilities, can be spray irrigated on the land. No waste need ever reach the rivers or lakes.
3. The wastes could be upgraded to a complete fertilizer by acidification with H_3PO_4 and neutralized again with NH_3 (ammonia).
4. If crops requiring a maximum amount of potash are grown, then crop removal would continually remove potassium as it is added in the waste. The crop could help pay for the increased cost of KOH.
5. The settleable solids could be used for livestock feed in a similar way to soda lye-peeled wastes. Potassium is an essential element for animals.
6. The same equipment could be used for KOH peeling as with soda lye peeling. KOH could be used for dry peeling also.

Methods and Materials

Russet Burbank potatoes grown in the Snake River Valley of southeastern Idaho were stored four to six months at 42° F. before use. Unbruised potatoes weighing from 150 to 175 gm. were immersed in hot KOH solutions to gelatinize the outer layers. The KOH solutions were made on a weight percentage basis. The potatoes were hand peeled under running water with a wire-handled 2 3/8- by 6-inch nylon cylinder brush until the yellow layer was removed and the pH was neutral. Optimum peeling conditions with the lowest peeling losses and/or smallest heat ring were desired.

Evolutionary operations (EVOP) procedure (4) was used to determine the optimum peeling conditions. The best combination of concentration of KOH, temperature of the KOH solution, and immersion time was determined. EVOP is helpful to optimize any process where many simple or complicated interactions affect the final product. It offers a simple way to increase plant efficiency and profitability.

Results and Discussion

Table 1 gives the EVOP results of an early experiment with a constant KOH solution temperature of 155° F. while varying KOH concentration and immersion time (min:sec.).

TABLE 1.--EVOP for peeling potatoes in constant temperature (155° F.) KOH solutions

Treatment No.	KOH concentration (percent)	Immersion time (min.:sec.)	Weight loss (percent)	Heat ring
1	18	4:30	Inadequate peeling	
2	22	4:30	do	
3	20	5:10	do	
4	24	5:10	do	
5	22	5:50	do	
6	26	5:50	16	0
7	24	6:30	18	0
8	28	6:30	28	0
9	30	5:50	29	0

The first three peeling treatments were obviously no good. Inadequate peeling occurred through the fifth treatment. The sixth set of conditions gave the best peeling with a minimum of peeling waste and no heat ring. Further EVOP after the sixth set of peeling conditions resulted in greater peeling losses and were undesirable. The optimum conditions at 155° F. were 26-percent KOH, 5:50 immersion time with 16-percent peeling loss and no heat ring. When the temperature was also varied in a later experiment, the optimum conditions were 25.5-percent KOH, 6:01 immersion time, and 154.4° F. temperature with peeling losses of 15.9 percent and no heat ring.

Further EVOP was performed at low temperature (<155° F.), high KOH concentration (>20 percent); middle temperature (160°-190° F.), medium KOH concentration (15-20 percent KOH); and high temperature (>190° F.), low KOH concentration (<15 percent). These tests all indicate that KOH peeling is feasible for potatoes. The flavor and economic factors must be favorable if the substitution is to succeed.

Preliminary tests with boiled and steamed potatoes indicated no flavor differences between KOH and soda lye-peeled potatoes. If excess potassium (K+) is present, there is a bitter, salty aftertaste. However, it should be possible to peel the potatoes until no significant residual K+ is present. If any hot or cold water treatments are performed, the potassium level should be even lower. The more strongly flavored products would be affected to a lesser extent than lightly flavored products.

The presence of certain salts of potassium may improve the quality of the processed potatoes. Cole (1) in 1965 obtained a patent wherein potassium phosphate plus KCl and NaCl in the presoak water produced potato flakes superior in both texture and flavor.

We are presently trying to find someone in Idaho to produce processed potato products after peeling with KOH. Taste panel tests will be run to compare with soda lye-peeled potatoes.

Higher yields of peeled potatoes (less peeling waste) were obtained with KOH compared to equal NaOH concentrations. However, pilot plant studies would be required to verify or reject this finding.

KOH is more soluble in cold water than NaOH. Plants using liquid solutions could buy more concentrated KOH solutions and save money on freight bills for the water. Better public relations would be a major benefit because very little or no water pollution should result.

The major disadvantage of KOH is the cost. KOH costs 25-40 percent more than soda lye. The cost per ton of peeled potatoes would be higher than with soda lye. If peeling costs are small compared to the cost of the final product, then conversion should be possible. If large volume uses for KOH are developed, the price should be lowered by higher and more efficient production techniques. The possible flavor defects from too much residual potassium could be a disadvantage.

The choice of whether to use KOH will depend on its advantages, or possible advantages, of better pollution control; returns from the waste products; the effect on quality; possible public relations advantages versus cost; and possible flavor problems with inadequate peeling. However, KOH does appear to offer a very good means to peel many fruits and vegetables, to lessen pollution, and to put the waste product to good use.

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ECONOMIC ANALYSIS OF ALTERNATIVE METHODS FOR PROCESSING POTATO STARCH PLANT EFFLUENTS[1]

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Introduction

The present requirements for the limits of pollutants in processing-plant waste water are necessary in order to preserve what is considered good water quality for natural streams. The effect of these requirements on potato starch plant operations is to place an economic burden on an industry which is already only marginally profitable. In present starch-making technology, practically all of the soluble components of the potato are released into the plant waste water. This yields an effluent which has both a high BOD level and a large daily flow. These two characteristics result in high sewage charges, that is, assuming the local sewage plant will accept the discharge at all. If the starch plant must build its own biological waste treatment plant, the costs--both capital and operating--will be substantial. An alternative method of treating the effluent is to recover the water-soluble constituents from the waste stream in usable form and sell them as byproducts. However, since the waste stream is dilute, recovery processes will have high operating costs and require considerable capital investment in relation to existing starch-plant valuation. Nevertheless, a byproduct recovery process could be justified if the selling price for the product or products resulted in a reasonable return on investment.

A preliminary economic evaluation of several potential waste treatment processes was made in order to see if any were commercially feasible. Since little pilot plant data had been obtained, this evaluation was primarily to see which process or processes deserved further investigation on the pilot-plant scale. The estimates are based on treating the waste water from a 30-ton-per-day starch plant operating 16 hours per day, 150 days per year. Five alternatives are compared. One alternative considers biological treatment of the waste with no recovery of the components of the waste as byproducts. The other four alternatives involve recovery of waste components and yield one or more byproducts. The waste stream was considered to come from a starch plant using current technology for starch recovery. The protein water waste flow used as a basis was approximately 104,000 gallons per day at a 2-percent by-weight dissolved solids concentration. This basis was considered an approximation of average starch plant operation using some improved water utilization.

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[1] Presented by R. L. Stabile at the Second National Symposium on Food Processing Wastes, March 23-26, 1971, in Denver, Colo., and published in the Proceedings of the Symposium (pp. 185-202).

Briefly, the five alternatives compared are: (1) biological treatment, (2) protein recovery with biological treatment, (3) concentration by evaporation, (4) protein recovery and concentration of protein-free waste, (5) protein recovery, ion-exchange and biological treatment. Let us look at the technology involved in each of the alternatives.

Alternative 1 - Biological Treatment of Waste

The treatment requirements for the waste treatment plant include at least 85-percent removal of BOD and suspended solids and complete removal of floatable and settleable solids. Other factors that must be considered for each plant location are the effect of the effluent discharge on the dissolved oxygen content of the receiving river or stream and the necessity for disinfection by chlorination. Chlorination is probably not required for starch plant waste treatment because pathogens are not present in the source of the waste.

The biological waste treatment process chosen is the activated sludge type. In this process, shown in figure 1, the raw waste is screened to remove fibrous solids, which are used as animal feed. The liquid containing

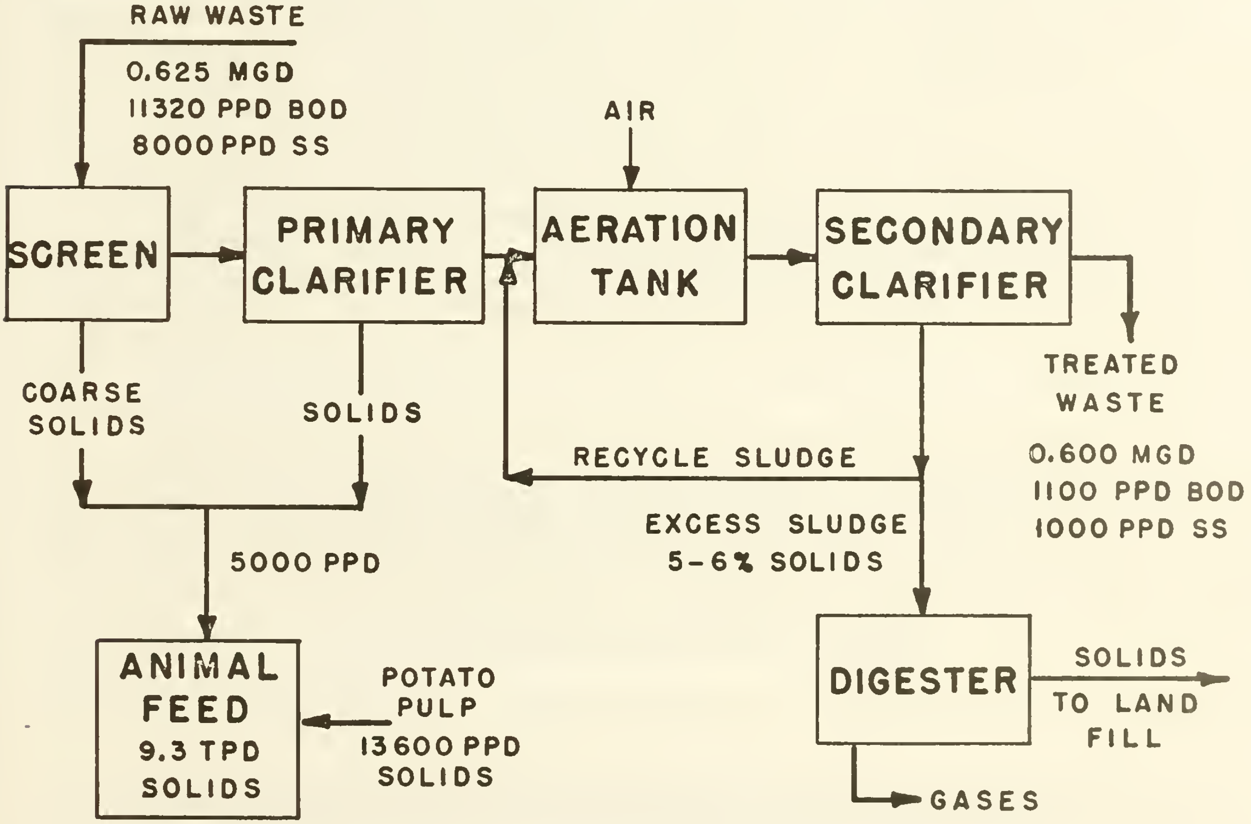

Figure 1.--Biological waste treatment by activated sludge.

suspended and dissolved solids is fed to the primary clarifier where settleable solids are removed. The solids removed from the primary clarifier are used in animal feed. The overflow from the primary clarifier goes to the aeration tank where biological degradation of the waste occurs. The effluent from the aeration tank is pumped to the secondary clarifier where the biologically active sludge is settled. Part of this sludge is returned to the aeration tank; the remainder passes to a digester where it is converted into gases and final solids by biological action. Final solids from the digester are assumed to be disposed of by land fill.

An activated sludge treatment system was selected because the design, operating procedures, and costs of this type system are well known, and also because it gives consistently high BOD removal.

The plant is assumed to process 625,000 gallons per day of waste water containing 11,320 lb. of BOD and 8,000 lb. of suspended solids. This total volume includes the combined protein water, wash waters from purifying the starch, and water used to flume and wash the raw potatoes. The treated waste sent to the river is approximately 600,000 gallons per day, containing 1,100 lb. of BOD and 1,000 lb. of suspended solids. Solids are removed from the screen and primary clarifier at a rate of about 5,000 lb. per day.

Alternative 2 - Protein Recovery and Biological Treatment

Protein recovery from protein water has been investigated by Strolle on a pilot plant scale (1). The results of this investigation were used to design a full-scale plant. The process is shown in figure 2. The protein water effluent from the starch plant, using the heated protein water from the steam injection heater, is preheated in a plate-type exchanger. After the preheating, sulfuric acid is added to an agitated tank which feeds the steam injection heater. The pH of the protein water is lowered to approximately 3.5; the exit temperature from the heater is 210° F. The precipitated proteins are removed from the slurry using a continuous rotary filter. The wet protein solids, containing about 87-percent water, are dried on a double drum dryer to about 5-percent moisture. The dried cake is ground and packed in 100-pound bags.

After de-proteinization, the waste stream is sent to a biological treatment process for removal of 80 percent of the remaining BOD, giving a final BOD of about 1,100 lb. per day. The biological process would be the same as described under alternative 1 except that incoming BOD would be reduced to 8,300 lb. per day because of the removal of the protein. Flow would be almost the same as alternative 1, and there would be no suspended solids. Therefore, a lower cost would be incurred.

Alternative 3 - Concentration by Evaporation

The basis for studying this process was to determine if it would be feasible to concentrate the entire protein water stream and make a profit by selling the concentrate for feed use.

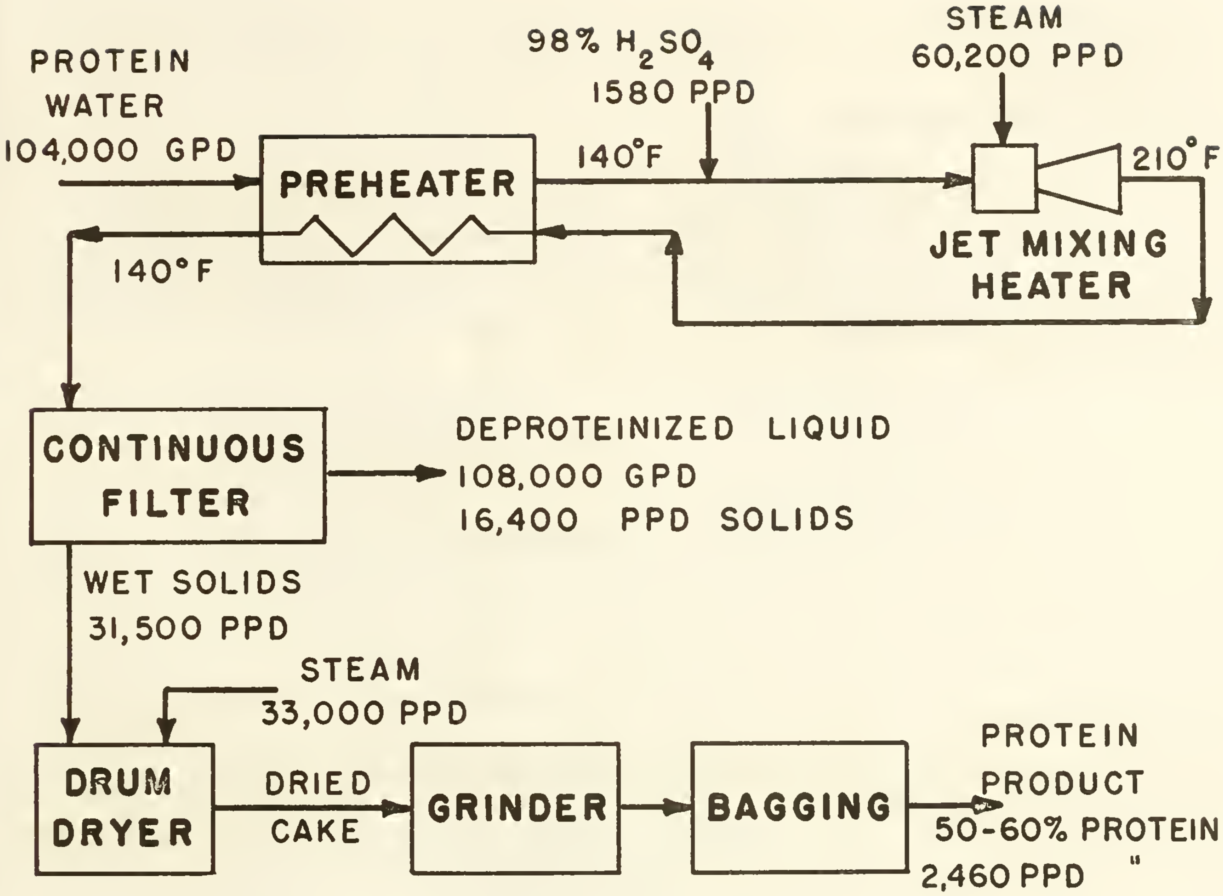

Figure 2.--Protein recovery from protein water.

The protein water is evaporated in a triple effect evaporator to a 60-percent solids slurry, as shown in figure 3. The slurry is mixed with the dried potato pulp from the starch process and the mixture is sold as animal feed.

Approximately 320,000 pounds per day of steam would be required for the evaporation.

The capital and operating costs are based on the evaporation step only. The cost for pulp drying is considered to be recovered through the sales value of the pulp constituent in the mixed feed product.

Alternative 4 - Protein Recovery and Concentration of Protein—Free Waste

This alternative was investigated because it was anticipated that a market might exist for both the protein and protein-free solids.

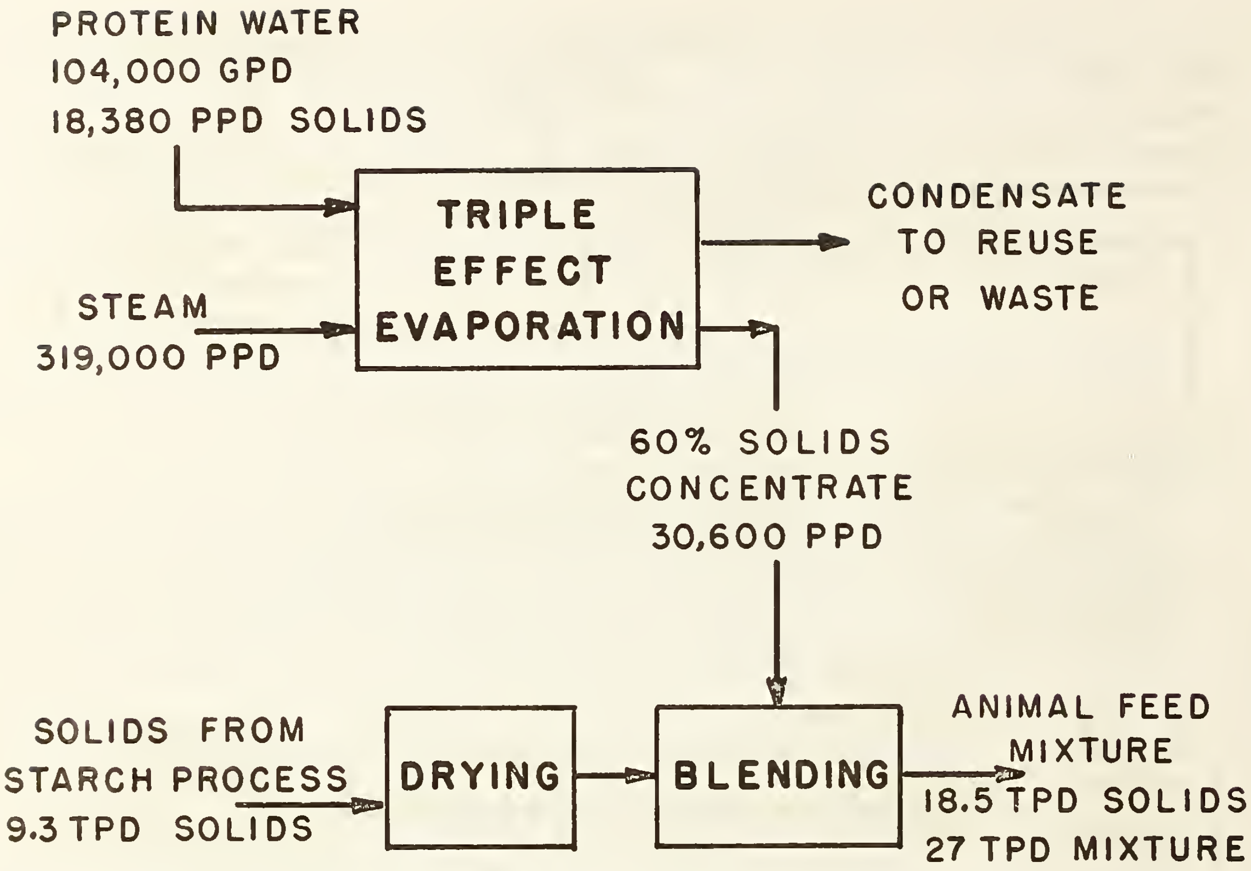

Figure 3.--Concentration of protein water by evaporation.

Figure 4 shows a schematic flow sheet of the process. The protein water goes first to the protein recovery process as described under alternative 2. The deproteinized liquid is evaporated in a triple effect evaporator as described under alternative 3.

Alternative 5 - Protein Recovery, Ion—Exchange and Biological Treatment

This alternative consists of the combination of the protein recovery process already described under alternative 2, an ion-exchange process which recovers potassium salts, amino acids, and organic acids (both as ammonium salts), and the biological treatment process described under alternative 1. Figure 5 shows these three sections of the process combined to form this alternative.

The protein water is first sent to the protein recovery process (4). It is necessary to remove the proteins first because they will precipitate on the ion-exchange columns if their concentration is 180 parts per million or more.

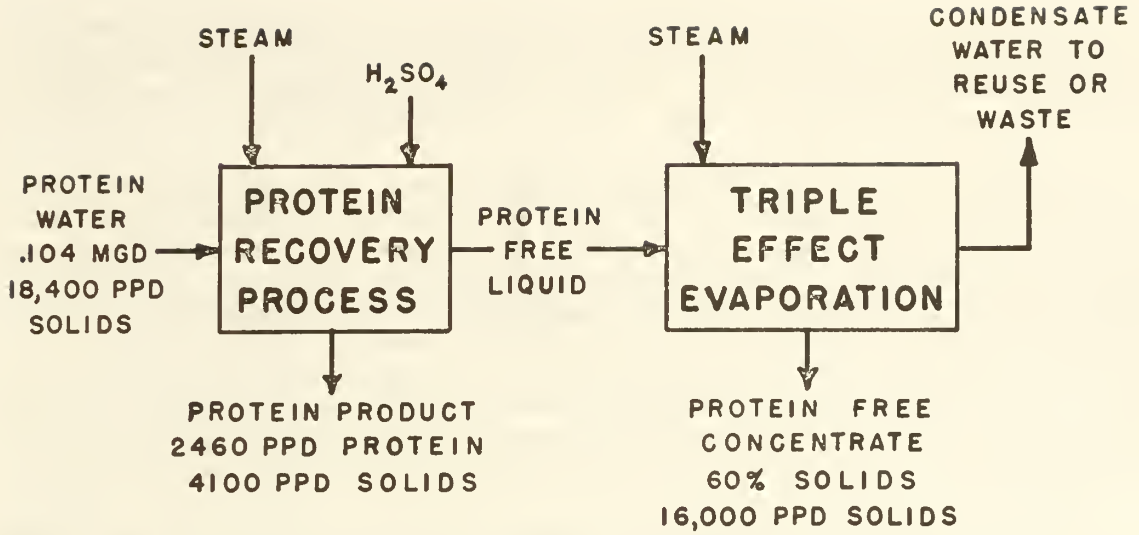
STEAM
H_2SO_4
STEAM
CONDENSATE WATER TO REUSE OR WASTE
PROTEIN WATER .104 MGD 18,400 PPD SOLIDS
PROTEIN RECOVERY PROCESS
PROTEIN FREE LIQUID
TRIPLE EFFECT EVAPORATION
PROTEIN PRODUCT 2460 PPD PROTEIN 4100 PPD SOLIDS
PROTEIN FREE CONCENTRATE 60% SOLIDS 16,000 PPD SOLIDS

Figure 4.--Protein recovery and concentration of protein-free waste.

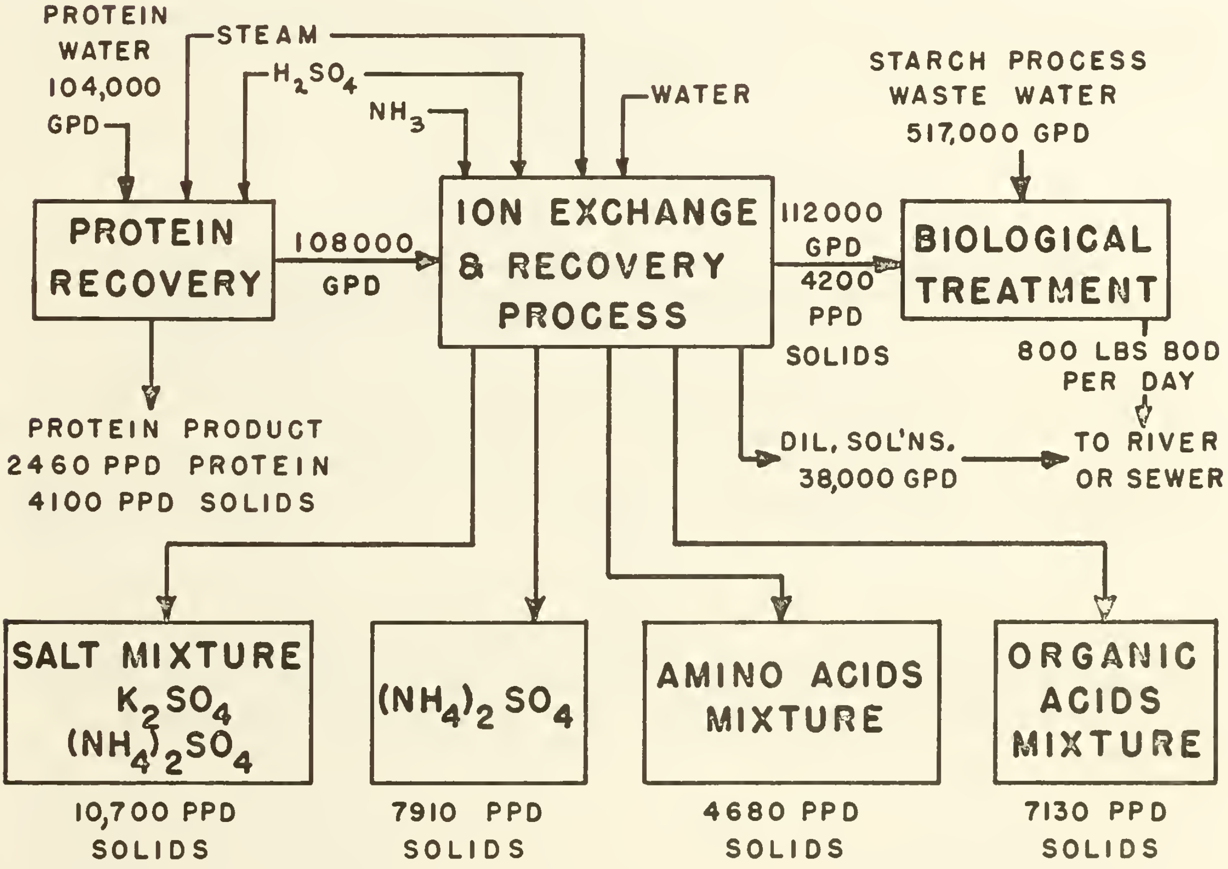

Figure 5.--Combination protein recovery, ion-exchange treatment, and biological waste treatment.

After protein removal, the waste is treated by the ion-exchange columns, which remove mainly potassium ions, amino acids, and organic acids from the waste stream (1, 2, 3). A final biological treatment removes most of the remaining dissolved solids, which are chiefly sugars.

Figures 6, 7, and 8 are schematic flow sheets showing the processing involved in the ion-exchange part of this alternative. In each of the three sets of ion-exchange columns, two columns are in series at one time performing adsorption and one column is being eluted and regenerated. Also, each byproduct solution resulting from ion-exchange is evaporated to 60-percent concentration before drum drying to 4-percent moisture. Figure 6 shows the potassium-ion removal by cation exchangers and recovery of solids by evaporation. After absorption and elution with sulfuric acid, an acidic solution is obtained which is neutralized with ammonia. The potassium and ammonium sulfate solution is evaporated and dried, yielding the mixed salt solid.

Figure 7 shows the amino acid removal from the potassium-free stream by cation exchangers. The adsorbed amino acids are eluted using ammonium hydroxide. The columns are regenerated with sulfuric acid. The amino acid and ammonium sulfate solutions are evaporated and dried. The amino acids are obtained as the ammonium salts.

Figure 8 shows the organic acid removal from the amino acid free stream by anion exchangers. The adsorbed acids are eluted using ammonium hydroxide solution. The organic acid solution is evaporated and dried to obtain the ammonium salts of the organic acids.

Costs

Capital and operating costs were calculated for each of the alternatives in order to determine which ones should receive further study.

Table 1 lists the capital costs of the alternatives in order of increasing fixed capital. Concentration of the protein water by evaporation requires the least fixed capital, with biological treatment next. Alternatives 2 and 4 are next, both requiring almost the same investment, alternative 4 being higher by about 10 percent. Alternative 5 requires an investment that is outside the range of the other four alternatives at $2,550,000.

Table 2 shows the operating costs for the alternatives, again in the order of increasing costs. The biological treatment process involves the least operating cost. Among the byproduct alternatives, concentration by evaporation incurs the least operating cost. The difference in operating cost between each consecutive alternative, as listed, is considerable, and much greater than the probable error involved in estimating the costs in this category.

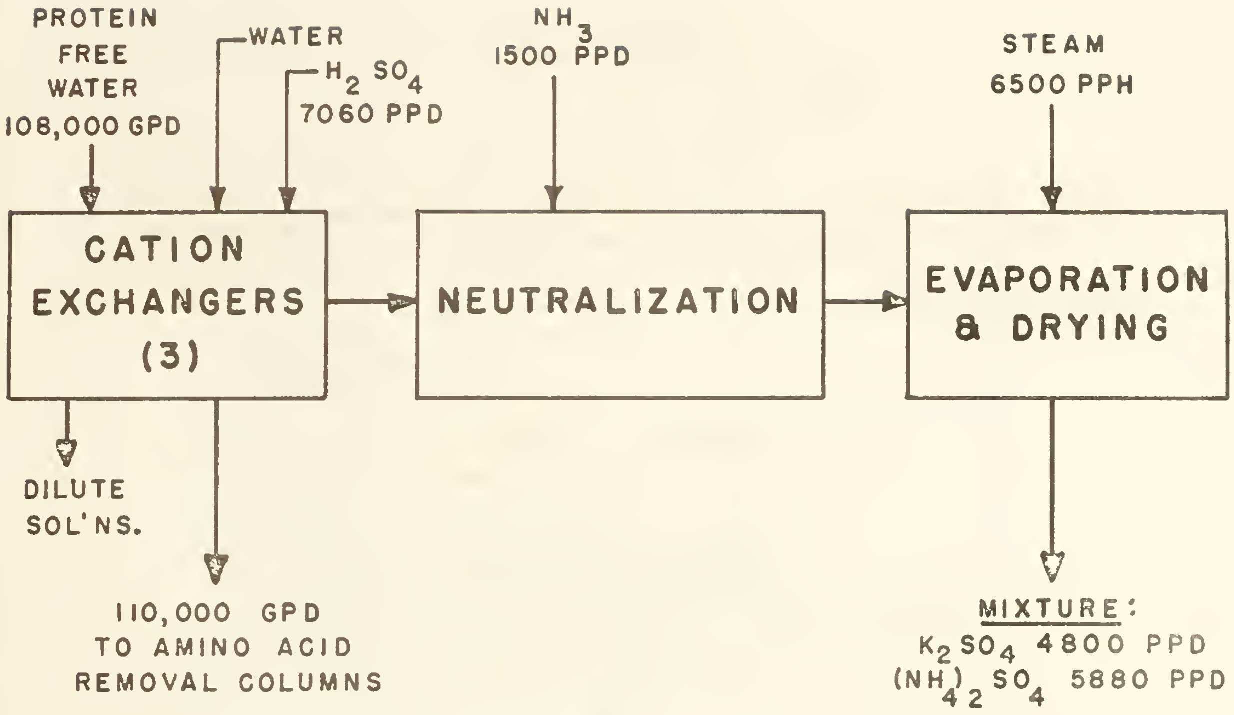

Figure 6.--Potassium ion removal and evaporation of solids.

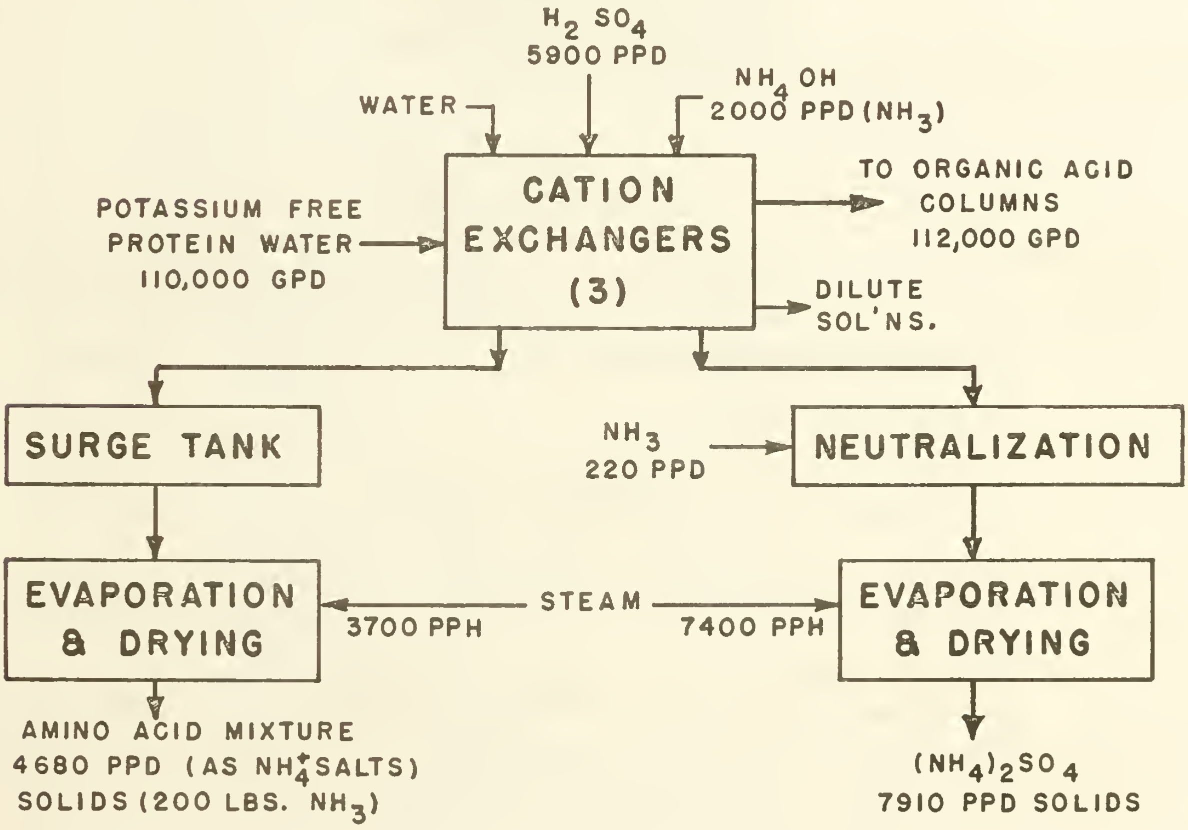
H_2SO_4 5900 PPD
WATER
NH_4OH 2000 PPD (NH_3)
POTASSIUM FREE PROTEIN WATER 110,000 GPD
CATION EXCHANGERS (3)
TO ORGANIC ACID COLUMNS 112,000 GPD
DILUTE SOL'NS.
SURGE TANK
NH_3 220 PPD
NEUTRALIZATION
EVAPORATION & DRYING
STEAM
3700 PPH
7400 PPH
EVAPORATION & DRYING
AMINO ACID MIXTURE 4680 PPD (AS NH_4^+ SALTS) SOLIDS (200 LBS. NH_3)
$(NH_4)_2SO_4$ 7910 PPD SOLIDS

Figure 7.--Removal of amino acids by cation exchangers.

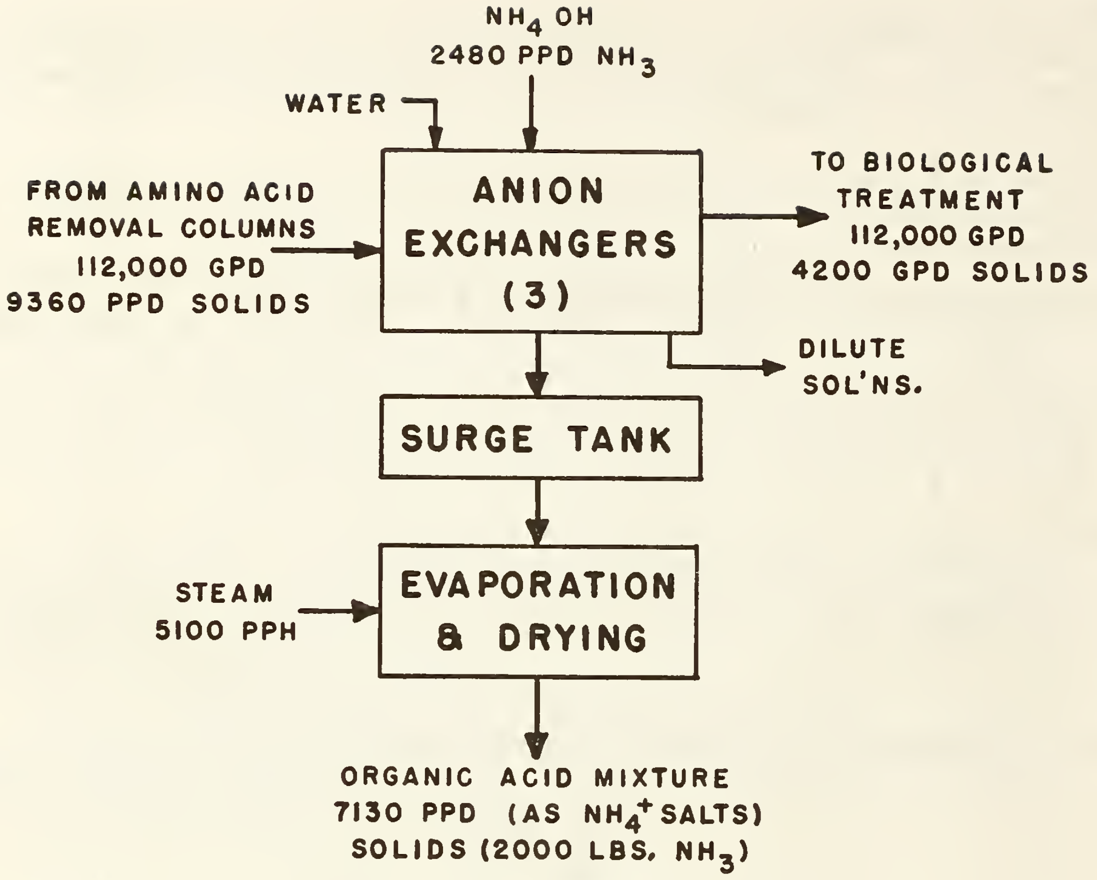

Figure 8.--Removal of organic acids by anion excnangers.

TABLE 1.--Fixed Capital Costs

Alternative No.	Alternative	Fixed capital ($)
3	Concentration by evaporation	514,000
1	Biological treatment	550,000
2	Protein recovery + biological treatment (Protein recovery = $382,000)	807,000
4	Protein recovery + concentration by evaporation	881,000
5	Protein recovery + ion-exchange + biological treatment (Biological treatment = $350,000)	2,550,000

TABLE 2.--Operating costs

Item	Alt. No. 1 Biol. treatment	Alt. No. 3 Conc. by evap.	Alt. No. 2 Prot. rec. + biol. treatment	Alt. No. 4 Prot. rec. + conc.	Alt. No. 5 Prot. rec. + ion exch. + biol. treatment
Daily					
Deprec.	238*	227**	347	383	1,538
Op. Ex.	367	764	974	1,494	3,500
Total	605	991	1,321	1,877	5,038
Yearly					
Deprec.	35,700**	34,000	52,100	57,500	230,750
Op. Ex.	55,000	114,500	146,000	224,000	525,000
Total	90,700	148,500	198,100	281,500	755,750

*Biological treatment, amortized at 7 percent for 20 years.

**Depreciation for alternatives 2, 3, 4, 5: Straight line method, bldgs. - 20 years, equipment - 15 years.

Table 3 shows the uses and estimated probable sales prices for the products obtained from the alternatives. The protein would be used for animal feed or possibly human food. The concentrate from the concentration-by-evaporation step is mixed with the potato pulp from the starch process, in the proportions in which they are produced, and used as cattle or poultry feed. The concentrate without protein, alternative 4, is also used as a feed additive, the price for this concentrate being lower than the concentrate with protein. The amino acid mixture could be used in feed or food. The price for this was estimated from current prices for amino acids. The organic acid mixture would be used in beverages as an acidulant. The price is considered comparable to similar acid mixtures used for this purpose.

TABLE 3.--Uses and estimated prices for products

Alt. No.	Alternative	Product	Use	Price (¢/lb.)
1	Biol. treatment	None	--	--
2	Protein rec. + biol. treatment	Protein	Feed or food	12.0
3	Conc. by evap.	Concentrate with protein	Animal feed	6.7
4	Protein rec. + conc. by evap.	A. Protein	Feed or food	12.0
		B. Concentrate without protein	Feed	5.0
5	Protein rec. + ion exch. + biol. treatment	A. Protein	Feed	12.0
		B. Amino acid mixt.	Feed or food	15.0
		C. Organic acid mixt.	Beverages	31.0
		D. K_2SO_4-$(NH_4)_2SO_4$	Fertilizer	2.2
		E. $(NH_4)_2SO_4$	Fertilizer	2.25

The potassium sulfate-ammonium sulfate mixture and the ammonium sulfate salts would be used as fertilizer. The prices were estimated from current prices for these chemicals.

Table 4 shows the daily and yearly sales using the prices for the products shown in table 3. The alternatives are listed in order of decreasing sales dollars. The differences in sales between alternatives as listed is probably greater than error in estimating the sales figures. Total operating costs from table 2 are subtracted from sales to give the gross income as shown in table 5.

It should be noted that the operating expense figures do not include an allowance for a return on the investment. Therefore, Federal income taxes are not included in the operating expenses. Thus, the net income after taxes for alternative 3 would be the amount shown in table 5 reduced by an amount equal to the Federal income tax. Also, the loss shown for the other alternatives would reduce the overall Federal income tax of the company by an amount equal to the loss shown times the tax rate.

TABLE 4.--Sales

Alt. No.	Alternative	Daily ($)	Yearly ($)
5	Protein recovery + ion exchange + biological treatment	2,960	444,000
3	Concentration by evaporation	1,244	186,700
4	Protein recovery + concentration by evaporation	1,100	165,000
2	Protein recovery + biological treatment	295	44,000
1	Biological treatment	None	None

TABLE 5.--Gross income or (loss)

Alt. No.	Alternative	Daily ($)	Yearly ($)
3	Concentration by evaporation	255	38,200
1	Biological treatment	(605)*	(90,700)
4	Protein recovery + concentation by evaporation	(777)	(116,500)
2	Protein recovery + biological treatment	(1,026)	(153,800)
5	Protein recovery + ion exchange + biological treatment	(2,078)	(311,750)

*Parenthesis indicates loss.

Table 5 shows the gross income or loss for each alternative in order of decreasing income (or increasing loss). Alternative 3, Concentration by Evaporation, shows the highest gross income, by far, of all the alternatives listed. Here again, the difference between the figures is greater than error in calculating the figures shown. After the alternative of concentration by evaporation, the biological treatment process has a smaller loss than the remaining byproduct recovery processes. From table 5 it is apparent that concentration by evaporation offers the only possibility for making an income, assuming the estimated selling prices for the various byproducts are reasonably correct.

Table 6, which shows selling prices for various levels of profitability, can be used to compare the effects of different prices on the commercial feasibility of the alternative.

TABLE 6.--Selling prices for various levels of profitability

Alternative	Product	Product selling price, ¢/lb.		
		To equal biol. treatment loss	To break even	Estimated market price
1. Biol. treatment	None	--	--	--
2. Protein rec. + biol. treatment	Protein	29.1	53.7	12.0
3. Conc. by evap.	Concentrate with protein	2.07	5.3	6.7
4. Protein rec. + conc. by evap.	A. Protein	13.9	35.1	12.0
	B. Conc. without protein	5.8	6.3	5.0
5. Protein rec. + ion exch. + biol. treatment	A. Protein	30.2	37.7	12.0
	B. Amino acids	37.7	47.1	15.0
	C. Organic acids	31.0	31.0	31.0
	D. K + NH_4 salts	2.20	2.20	2.20
	E. $(NH_4)_2SO_4$	2.25	2.25	2.25

For alternative 2, the table shows that the protein must be worth almost 54 cents per pound for no loss to occur. This is greater than the estimated selling price of 12 cents per pound. This means that, at current prices for protein, the process is not commercially feasible. In contrast, alternative 3 has a break-even price lower than the estimated price of 6.7 cents per pound. Of course, any price between 5.3 cents, the break-even price, and 6.7 cents will involve no loss or some income will be earned. Thus, there is a likelihood for income for alternative 3 with current prices for feed. The nutritive value of the feed consisting of pulp mixed with protein concentrate was estimated at 20 percent above that of corn at $47 per ton. On this basis, the concentrate alone was estimated to be worth $73.50 per ton at 60-percent solids or 6.7 cents per pound of moisture-fre solids. It is possible that a higher price could be obtained if the concentrate were fed to nonruminant animals, since the protein is of excellent quality (5).

Under alternative 5, only the prices for protein and the amino acid mixture were varied in order to obtain the additional income required for the condition of "break-even" and for the condition of "loss-equal-to-biological-treatment."

Table 6 also shows the selling prices of the products for the condition where the gross loss for the alternative would equal the loss for the biological treatment alternative. There is only one alternative shown where the estimated actual market price exceeds both the break-even price and the loss-equivalent-to-biological-treatment price, and that alternative is concentration by evaporation.

Conclusion

We have seen the results of a preliminary economic evaluation of a number of possible methods of treating the waste effluent from potato starch plants.

Conventional biological treatment of the waste water appears to have both rather high capital and operating costs.

Four of the treatment processes yield products, and revenue from the sale of these products would help offset the operating costs. Only one of these processes, however, appears economically feasible at this time--namely, concentration of the effluent by evaporation. Our laboratory is, therefore, investigating this process on the pilot plant scale. These studies will enable us to project commercial feasibility with greater confidence and also make available samples of the product for testing and evaluation. When further information on this process has been obtained, we will publicize the results.

Development of the protein recovery process on a pilot plant scale was carried out in our Engineering and Development Laboratory by E. O. Strolle. The ion-exchange processes for recovery of inorganics, amino acids, and organic acids were carried through the laboratory scale by E. G. Heisler, J. Siciliano, and J. H. Schwartz of our Plant Products Laboratory. Much of the basic data needed for process design in our economic analysis were provided by these individuals.

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A GRADING SYSTEM FOR PEELED POTATOES

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During the development of the Infrared Peeling Process, we have performed a large number of laboratory experiments for Magnuson Engineers at my laboratory in Idaho Falls. These experiments have determined the best conditions for peeling various grades and varieties of potatoes for making processed products such as french fries, dehydrated mashed potatoes, and potato chips.

In the past, most laboratory peeling tests have been evaluated by simply measuring the weight loss of the peeled potato. An arbitrary standard of quality for the peeled potatoes has been assumed by the investigator. As an example, when peeling potatoes for french-fry production, the investigator has used as the standard his impression of the quality of potatoes normally used in a french-fry production line. These, of course, are well-peeled potatoes requiring a minimum of trim labor.

Difficulties arise, however, when interpreting peeling test results by this method because of the absence of a definite grading system. Very few investigators will use the same quality yardstick. Also, potatoes used for making instant mashed potato products, such as potato flakes or potato granules, require less removal of peeling than do frozen french fries. The same is true for potato chips. To express the results of peeling experiments for these products on a weight loss basis only would require a different arbitrary standard for each product.

To overcome this problem we have developed a grading system for peeled potatoes to evaluate peeling tests. By measuring the quality of the peeled potatoes on this scale, it has been possible to determine much more accurately the most efficient process conditions to remove the peel and defects with minimum peel loss for any desired final quality.

Through careful evaluation of many peeled potato samples, we found that potatoes could be graded satisfactorily on a seven-point scale. It had to be recognized that there are some defects on a potato that could not be removed by any peeling process. These are ignored in the grading. Attempts with a five-point scale left too many in-between judgments. The seven-point scale purposely includes a fully peeled potato at the top of the scale, Grade 1, and a practically unpeeled potato, Grade 7, at the other end.

The grading system finally established is as follows:

	Description
GRADE 1.	A perfect peeled potato: no skin remaining, all eyes and all defects peeled clean. The only exceptions would be defects such as deep bruise, penetrating into the potato, judged to be unpeelable. Normally this condition would be considered "over-peeled."
GRADE 2.	A well-peeled potato: one or two very small specks of skin left on the surface or in an eye cavity.
GRADE 3.	A fairly well-peeled potato: several very small spots of skin may be left or some of the cortical layer may remain in the deeper eyes. There may be one patch of skin or a defect which might be trimmed off for french fries. This grade is fully acceptable for french-fry production, as the defects would be considered minor.
GRADE 4.	This grade does not appear well-peeled, having either multiple peel fragments or defects remaining. It could also have a very faint layer of outer cortical cells remaining. These potatoes would not be acceptable for production of french fries without trimming, but would be fully acceptable for dehydrated mashed potato manufacture.
GRADE 5.	This grade shows 5 to 50 percent of outer periderm or outer cortical cells remaining. These potatoes are generally unacceptable for use in dehydrated potato manufacture.
GRADE 6.	Some peel removed but anywhere from 50 to 90 percent of either the periderm or outer cortical layer remains. Completely unacceptable for processing. A very poor peeling effort, generally occurring during trials for minimum conditions.
GRADE 7.	A well scrubbed potato with less than 10 percent of outer peel removed resulting from extreme test conditions.

The use of the peeling grade scale can perhaps best be illustrated by describing our laboratory procedure used for comparing various methods or conditions of peeling. All tests within a series are performed on the same lot of potatoes in as short a time as possible, usually the same day. Potatoes are selected weighing about 250 grams (about 9 oz.) to minimize the size effect; those with cracks, badly rotted or clipped ends, or second growth knobs are not used.

The potatoes are washed and blotted dry with paper towels before peeling. After being weighed, they are immersed singly in caustic solution maintained at the desired temperature. A holding period is then simulated by placing the potato in a covered container at room temperature.

For experiments using infrared peeling, the potatoes are irradiated under two standard Lambert gas burners while supported and turned on two 3"-diameter rollers. These rotate at 10 r.p.m., the same speed used in the Magnuson Infrared Processing equipment.

After heat treatment, the peels are removed by a rotating rubber-tipped plate in a vegetable peeler adapted for this purpose. While this unit does not give the intense scrubbing action used in the commercial Magnu-scrubber, experiments have shown that substantially all of the softened material is removed. After peeling, the potato is blotted dry, weighed, graded, and then dipped in a 0.5-percent sodium bisulphite solution to prevent surface darkening. All peel losses are adjusted to a standard 250-gram potato using a curve relating the peel loss to weight of potato. This curve was determined experimentally by carefully hand peeling Idaho Russet potatoes (figure 1).

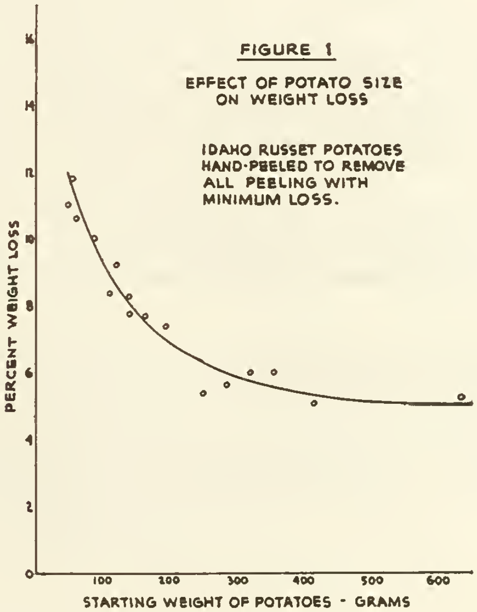

FIGURE 1

EFFECT OF POTATO SIZE ON WEIGHT LOSS

IDAHO RUSSET POTATOES HAND-PEELED TO REMOVE ALL PEELING WITH MINIMUM LOSS.

In most experiments, immersion time in the caustic is adjusted over a range to give a quality variation from Grade 1 through Grade 5. Enough potatoes are tested to minimize variations resulting from unequal response of potatoes to peeling conditions. Sufficient points are made to determine the slope of the peel loss versus quality grade curve for each of the variables.

For example, figure 2 shows the increase in peel loss as a function of the immersion time in caustic for a typical experiment. Idaho Russet potatoes that had been stored under ideal conditions for 10 months were treated in 9.6-percent caustic at 190° F. for times ranging from 0.33 minutes to 2.0 minutes. Following a holding period of 3 minutes, the potatoes were exposed to infrared radiation for 1.5 minutes. The quality of each of these peeled potatoes was determined according to the grade scale described in this paper. These results are shown in figure 3, again plotted against the caustic immersion time.

The relative efficiency of these processing conditions in peeling these particular potatoes is best shown by plotting the quality grade of the peeled potatoes against the peel loss, as shown in figure 4. The gradual improvement in quality can be seen, as expected, as a direct function of the increased removal of external potato tissue. To compare any two methods or conditions of peeling, similar curves are obtained on the same lot of potatoes.

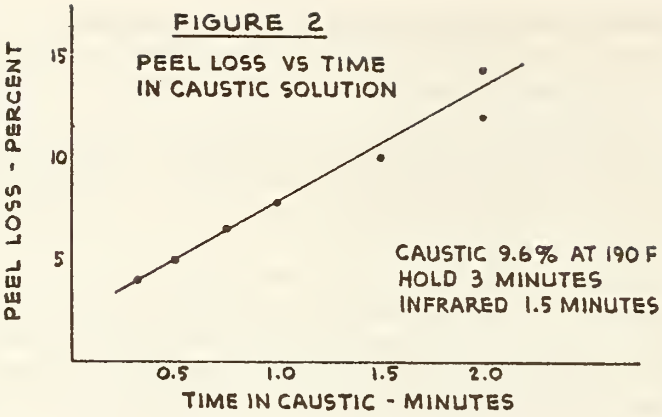

FIGURE 2

PEEL LOSS VS TIME IN CAUSTIC SOLUTION

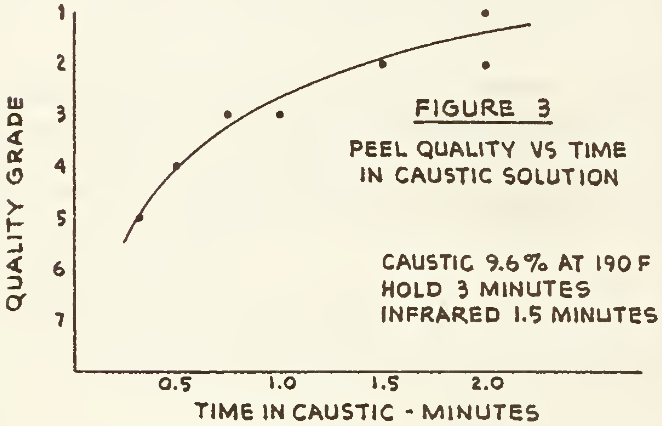

FIGURE 3

PEEL QUALITY VS TIME IN CAUSTIC SOLUTION

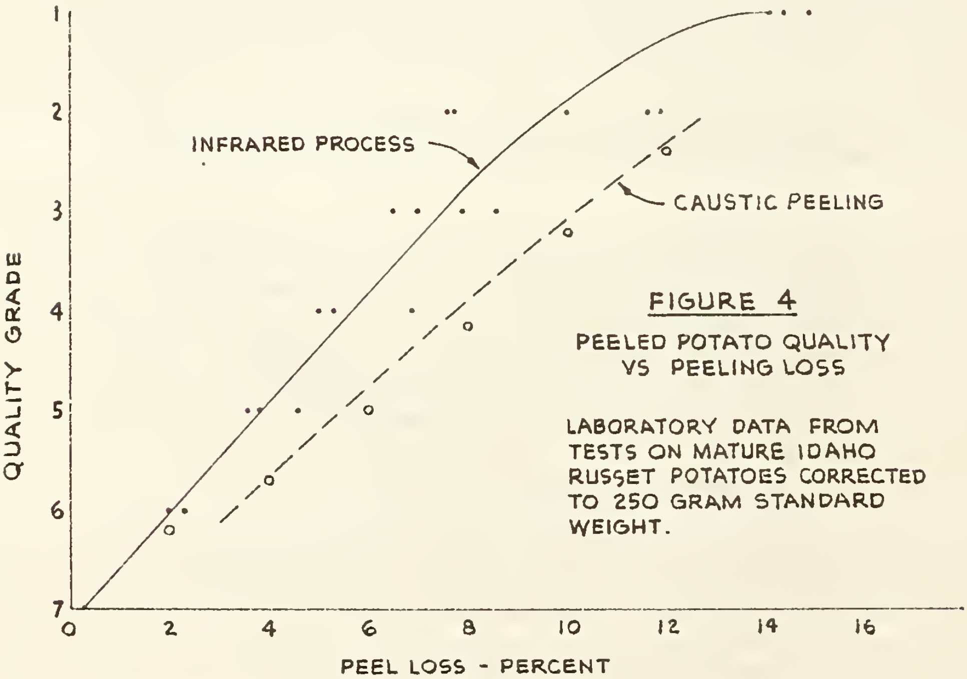

FIGURE 4

PEELED POTATO QUALITY VS PEELING LOSS

LABORATORY DATA FROM TESTS ON MATURE IDAHO RUSSET POTATOES CORRECTED TO 250 GRAM STANDARD WEIGHT.

A comparable quality-versus-peel loss curve obtained by caustic peeling Russet potatoes is also shown in figure 4. This is a composite curve of several experiments, summarizing most of our experience with various conditions of caustic treatment on Idaho Russet potatoes. These two curves illustrate the significant reduction in peel loss made possible by using infrared peeling compared to caustic peeling. For example, to obtain a Grade 3 quality potato required 8-percent peel loss on the average with the infrared process; to obtain the same quality, a 10.5-percent loss was necessary with caustic peeling.

Expressed differently, a hypothetical plant peeling with an average loss of 8 percent measured on potatoes averaging 250 grams would have obtained an average Grade 3 quality if infrared peeling had been used. If traditional caustic peeling had been used at an 8-percent peel loss, the average quality of the finished potatoes would be slightly below Grade 4 and extensive trimming would have been required to manufacture french fries.

If, on the other hand, the plant required an average Grade 4 peel for making potato flakes, the caustic peeled potatoes would have been peeled adequately at an 8-percent loss. However, with infrared peeling, the loss would have been reduced to 6 percent with the same quality.

These comparisons are valid only for potatoes with an average weight of 250 grams. For potatoes with a different average weight, a correction can be estimated from the size-versus-weight loss curve shown in figure 1.

Most comparisons of peeling processes deal with completely peeled potatoes--those with a Grade 2 or Grade 3. Grade 1 would be considered overpeeled by most potato processors, although a certain proportion of any lot of potatoes peeled to an average of Grade 2 will contain a representative number of completely peeled potatoes. The peeling grading system makes it possible to interpret comparative scores in peeling tests for the manufacture of any processed product.

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